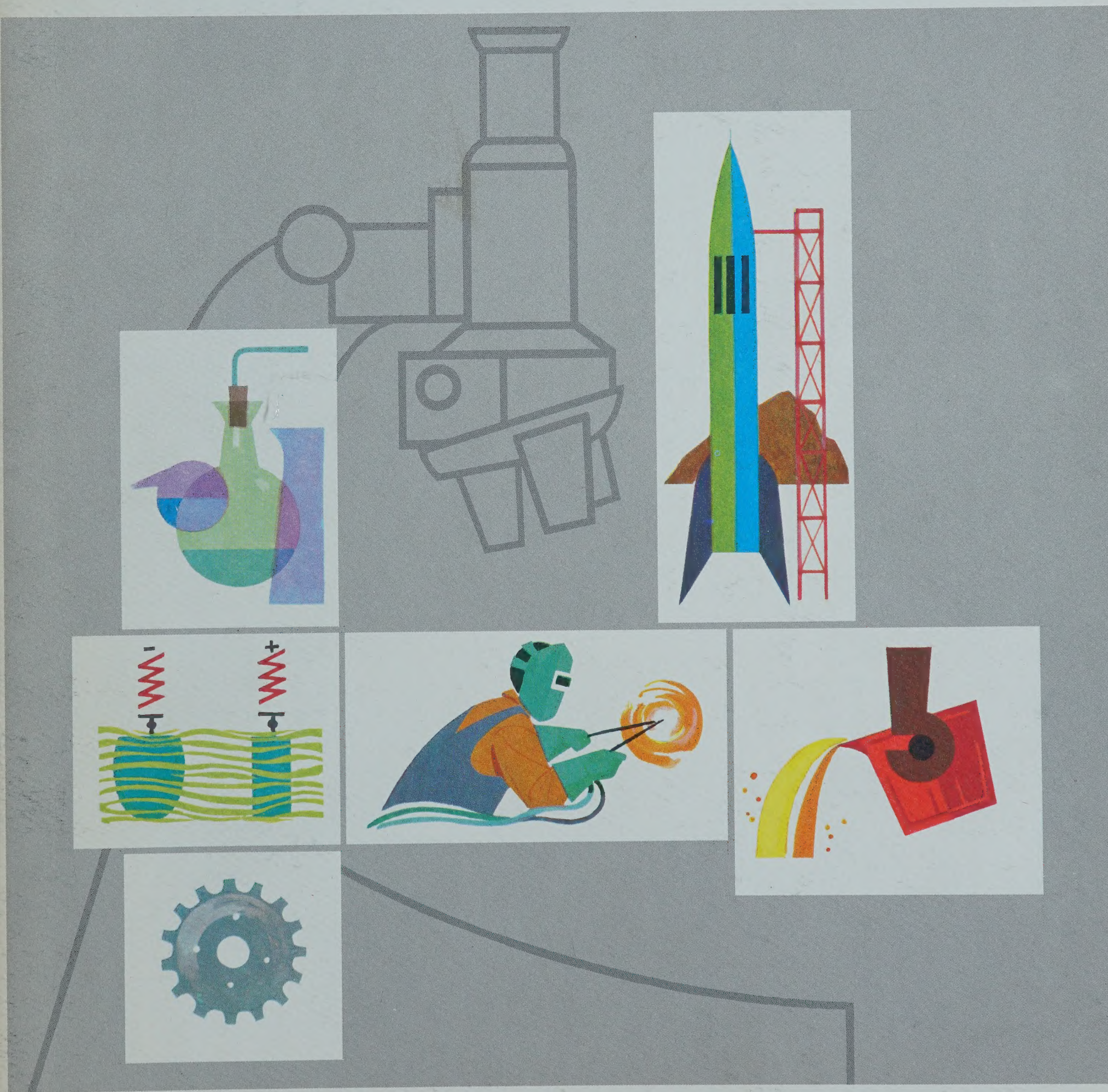
inco

WINTER 1964-65



NEW NICKEL MINES

Depicted here are International Nickel's two newest operating mines in the Sudbury District of Ontario—Clarabelle Open Pit and Crean Hill.

Today's improved open-pit methods, modern equipment such as giant electric shovels and rotary drills, and advances in metallurgical processes make it economically feasible to mine low-grade ore at Clarabelle, International Nickel's only operating surface mine.

Crean Hill (below) is one of seven underground mines—six in the Sudbury area and the Thompson mine in Manitoba. Annual total ore production at all eight mines is more than 13 million short tons.

Two additional underground mines—Copper Cliff North in the Sudbury District and Birchtree near Thompson—are currently under development.

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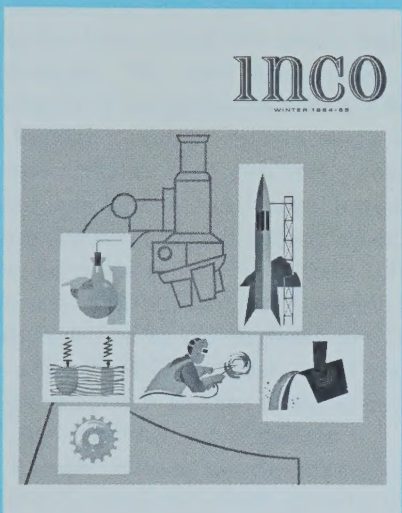


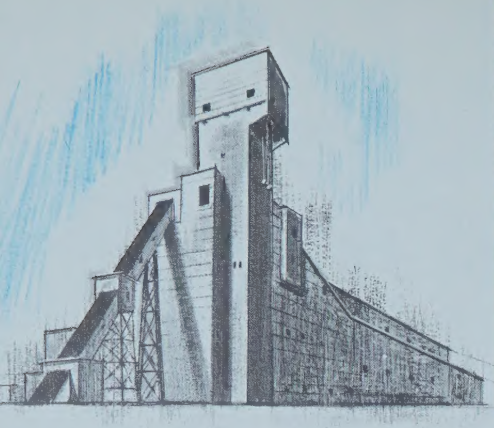
Our cover symbolizes scientific research and the industrial fruits reaped therefrom. Research—specifically the research conducted by International Nickel—is also the subject of our lead article.

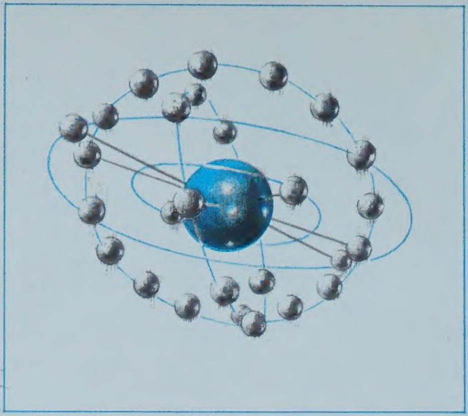
In this issue . . .

THE INTERNATIONAL NICKEL COMPANY OF CANADA, LIMITED

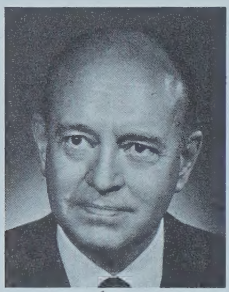
55 Yonge Street, Toronto 1, Ontario, Canada

Producer of Inco Nickel, Nickel Alloys, ORC Brand Copper, Tellurium, Selenium, Sulphur, Platinum, Palladium and other Precious Metals; Cobalt and Iron Ore.





INTENSIFYING THE SEARCH



by
Henry S. Wingate, Chairman
The International Nickel Company of Canada, Limited

The presence here of many leaders in research, industry and education is a tribute which we greatly appreciate. It is an inspiration to all of us at International Nickel—particularly those who will be carrying on the work of this institution. Your support makes clear that we are together in a common cause—to gain insight from each other's pioneering efforts—to share in the success of our various explorations.

I am inclined to think it must have crossed your minds, when you arrived here today, that here is a most fortunate use of nature—everything in sharp contrast with the atmosphere and pressures of the centers of commerce and industry, where most of us spend our working lives. Certainly, we enjoy here a favorable environment for the pursuit of creativity and useful knowledge. The transfer of International Nickel's heritage in research to these fresh surroundings can only make our investigations more unfettered and more productive.

Mr. Wingate delivered this address at the dedication of International Nickel's new research facility in Sterling Forest, Orange County, New York, on October 29. Concurrent with the dedication of the Paul D. Merica Research Laboratory, International Nickel's laboratory in Birmingham, England, is being expanded and modernized. And the dedication occurred a little over a year before the scheduled opening of another new nickel research center — this one in Toronto. These new and expanded facilities represent an intensification of International Nickel's more than 60-year-long search for new and better ways to use nickel.

We have named this center the Paul D. Merica Research Laboratory. It is a clean-cut new facility but, in reality, only the setting, the building, some of the apparatus and the layout of activities are new. Research at International Nickel goes back to the beginnings of the company in 1902.

Our annual report for that year reported on our efforts to introduce nickel for new applications, and it stressed the importance of these efforts to our future success. By 1919, research had become a major activity. Dr. Merica in that year came to us from the Bureau of Standards in Washington. Soon, he became director of research and gave inspiring leadership to our work. He helped make it of central concern to us to know all we can of the ways in which nickel can create a better or less costly product.

Dr. Merica's likeness is portrayed in nickel silver in a plaque placed in the main entrance. This laboratory is a tribute to him as a renowned physical metallurgist and fifth president of International Nickel, and it is a testimonial to how our directors assess the performance record of the men who have constituted our research staffs, as well as to our conviction in the continuing value of research.

Research Accomplishments

Inco's research teams have scored many accomplish-

ments. One notable achievement helped make jet transportation a practical reality. Early in World War II, Sir Frank Whittle, the inventor of the first successful jet engine, came to us with a request for an alloy that would retain its strength at 1,000 degrees F. In less than a year, it was our laboratories which produced the high-temperature alloy that met Sir Frank's requirements.

Since then, new and dramatically more powerful engines have called for much higher levels of heat resistance. We now have alloys that keep their strength at temperatures above 1,800 degrees F.

Whittle's request led to a whole series of alloys for many different uses. Just this week, the Ford Motor Company announced the development of a prototype turbo-driven truck—a vehicle especially designed for the National Highway System scheduled for completion in 1970. The truck's engine is the latest application of one of our high-temperature alloys known as alloy 713LC. It must resist gas temperatures as high as 1,750 F and the stress of turbine operation at 75,000 revolutions per minute.

I might turn to another example of International Nickel's research, which goes to the lower extreme of the thermometer. A petroleum producer was studying a method of dewaxing gasoline by taking it down to extremely low temperatures. A steel was required for piping and containing vessels that would retain its toughness under those severe conditions. To meet this need we succeeded in developing an alloy steel (and later, a series of steels) that today serves a whole range of cryogenic uses.

As most of you know, the greater use of liquefied gases in industry—and especially of oxygen in steel production—has created a highly important demand for new alloys to transport and store them. Oxygen and other gases are best stored in liquid form—and this requires vessels and piping that can retain both strength and toughness under high pressures and low temperatures. It was Inco research that provided an alloy steel for this purpose. Within our own smelting operations in Ontario, Inco itself is making extensive use of this steel in a major expansion of our oxygen-producing capacity.

A significant new cryogenic application has gone into a recently built French ship — the *Jules Verne*. It will transport natural gas from Algeria to France in liquid form, thereby concentrating huge amounts of gas in relatively limited cubic space.

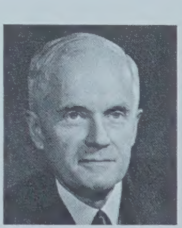
Research in International Nickel's laboratories has also led to several series of maraging steels. Maraging is a metallurgical process for strengthening ferrous alloys. Its development involved challenging, and then blasting, the accepted hypothesis that carbon is necessary to strengthen steel. As a result of this rethinking by our research staffs, high-strength maraging steels are now produced throughout the steel industry. They have their greatest initial demand in the field of aerospace.

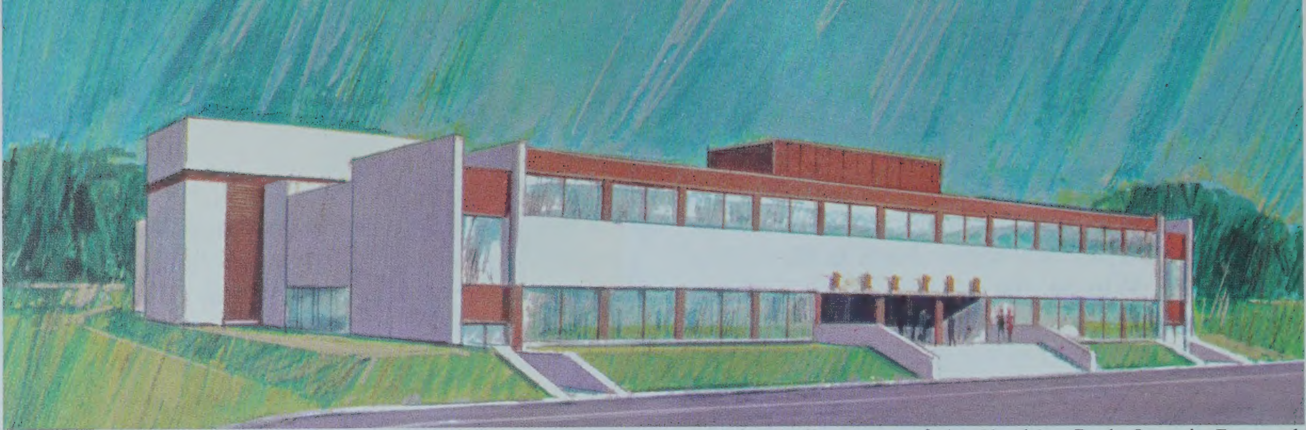
New Maraging Steel

Today I am able to announce the extension of the maraging concept from the nickel-*cobalt*-molybdenum system to a nickel-*chromium*-molybdenum system. Our own investigations, extended by intensive work among members of the steel industry, have now established this additional basic type of maraging steel—at the 12 per cent nickel level—with high yield strength, impressive resistance to fracture, and with

The Paul D. Merica Research Laboratory occupies over three acres of a 150-acre tract on the shores of Blue Lake in Sterling Forest, a research and educational community in Orange County, some 45 miles north of New York City. The H-shaped building, contemporary in design, has a steel, glass, fieldstone façade, with nickel stainless steel copings, trim and hardware. There are over 200,000 square feet of floor space in three wings. It is named for the late Paul D. Merica.

Paul Dyer Merica, the renowned metallurgist for whom International Nickel's new laboratory was named. Dr. Merica, a former president of International Nickel, directed the establishment of the organization's first full-scale laboratory in Bayonne, New Jersey, in 1924.





An artist's sketch of the new International Nickel research center now being built as part of the Sheridan Park Ontario Research Community near Toronto. The laboratory will conduct process research to develop processes for extracting and refining nickel and other elements from its ores. It will also conduct product research aimed at developing new nickel applications, as well as geophysical and mineralogical research. The research center is expected to be completed about the end of 1965.

ease of heat treatment and fabrication.

This new grade of steel has potential for aerospace and hydrospace uses, along with missile applications. Steel producers will be prepared to offer it commercially in a variety of product forms. We regard it as a major development.

Many new steels are expected to follow in the maraging family. Thus, one line of our current research, still in its early stages, gives promise of *corrosion-resistant* maraging steels—without loss of the principal advantages associated with present maraging steels.

Research Approach

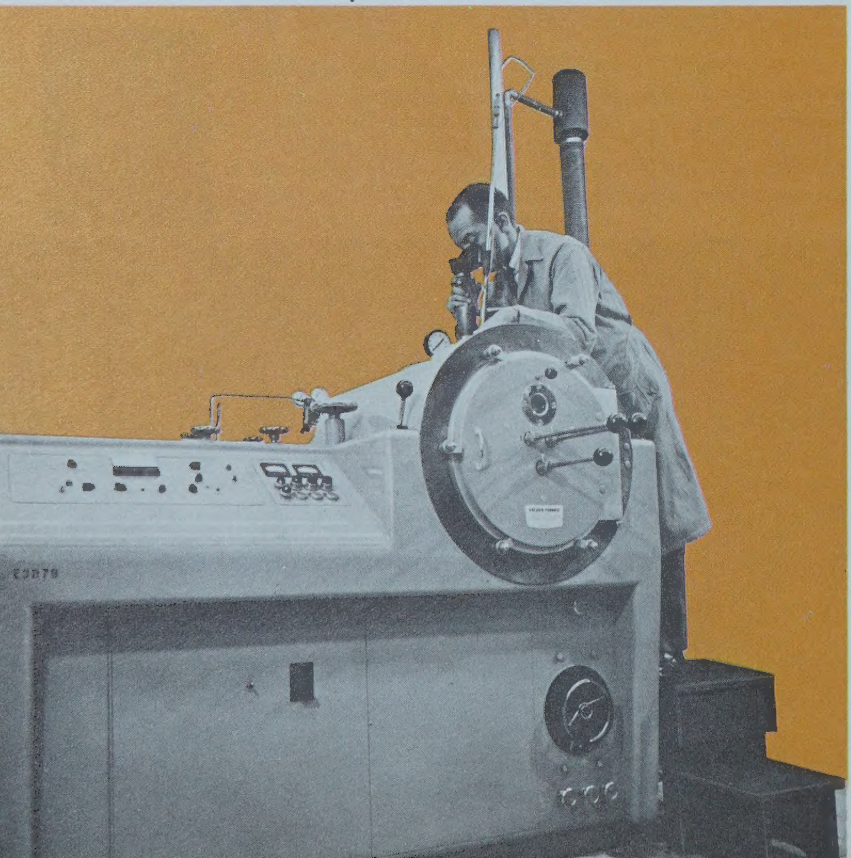
The work of International Nickel's laboratories has been basically oriented to the needs of industry and all echelons of consumers. It is these needs which determine the priority of programs undertaken by our research staffs. We engage ourselves primarily in two lines of research: One—*to develop new nickel alloys;* and two—*to study those factors* (composition, temperatures, pressure, processing or whatever) *that control the properties* associated with these alloys.

Our research people are encouraged to conduct programs that solve problems, like—Why does a certain alloy lose its strength above such and such a temperature? And—what factors of structure and chemical composition determine the properties of an alloy at elevated temperatures?

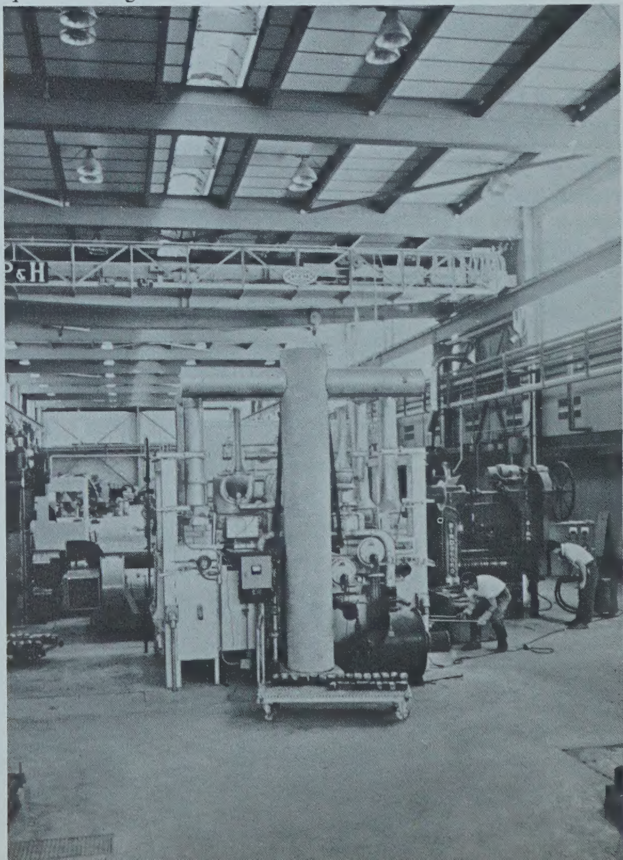
These questions are not formulated in a vacuum, but rather they originate in industrial or consumer needs.

Our people are in close touch with our customers. They locate prospective applications and they define

The first objective of research at the Merica Laboratory is the development of new alloys containing nickel, including steels, cast irons, and nickel-base, copper-base and aluminum-base alloys. After preliminary stages, a development project usually moves to the bench laboratories. At this intermediate state, experimental alloys are produced in small quantities under strictly controlled conditions.



In the laboratory's large pilot-plant areas, alloys can be developed to a stage that considerably narrows the time between invention and acceptance by industry. This is usually not possible in a laboratory. After experimental alloys are melted and cast by a variety of methods which are standard industrial practice, they are forged and hot- and cold-rolled for subsequent testing.



the requirements of these applications in terms of the conditions under which an alloy must perform. The specific properties necessary to deal with these conditions are determined, and our research staffs study, identify and interpret the critical factors that will be capable of creating the required properties.

We don't try to set up fixed boundary lines between fundamental research or applied research. We look for that research which we think would have the capacity to throw light on problems relative to our industry and to our customers. The ability to formulate in advance the creative questions to be pursued is critical. Inevitably, our questions relate to the nature and potential of nickel and its behavior with other metals, rather than to questions primarily concerned with the ultimate atomic and electrical nature of matter.

In posing the questions to be explored, we accept the risk that many lines of inquiry will prove unproductive, but our experience gives basis for confidence that an ample proportion of questions will be answered with rewarding results.

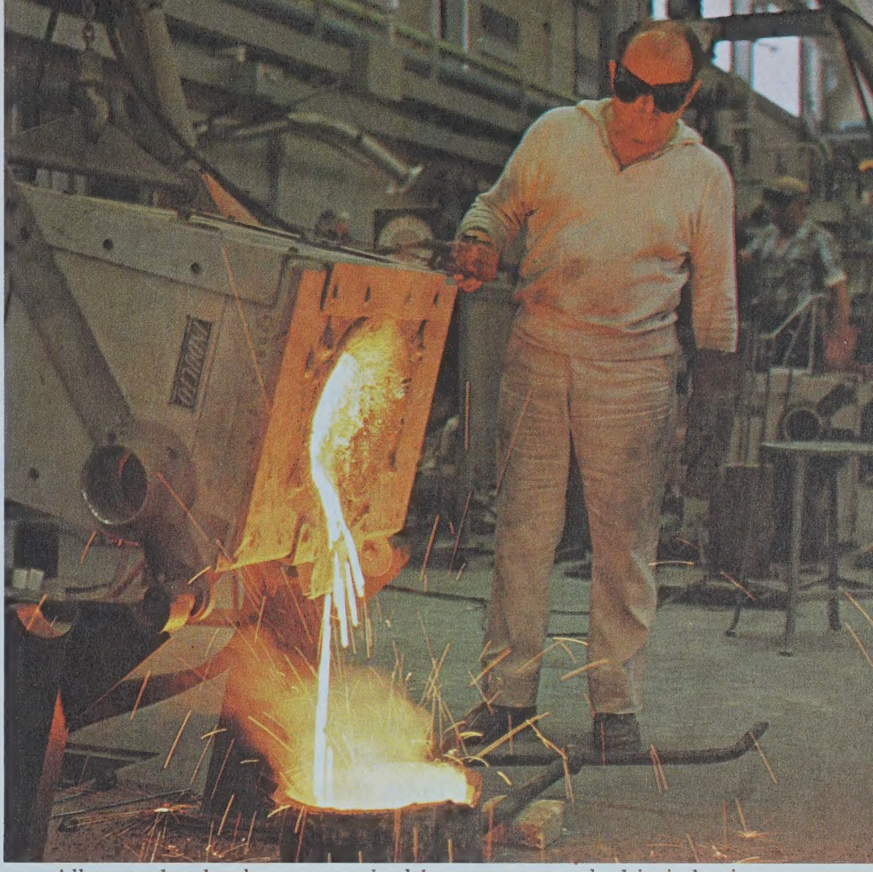
As you have gathered, the mission of research at International Nickel is closely related to the worldwide marketing role of International Nickel. Our research is committed to the service of our customers and their customers' customers—because our present and our future depend on their assessment of the value of our services. I am speaking of the services of nickel and our other products (in all their forms) in assuring quality and efficiencies to the end-user, and in providing market opportunities for those who directly buy our products. Also, I am referring to the help we are able to give by dissemination of reliable technical data from the reservoir of specialized knowledge we have accumulated, by the constant development of new knowledge, and by focusing attention on the economic and commercial significance to others of what we have learned.

The Future

Looking forward, our purpose is to have many new developments—in the maraging steels, in the stainless steels, in nickel-base alloys, in copper-base alloys and, looking further into the future, in alloys based on the more exotic elements, such as columbium.

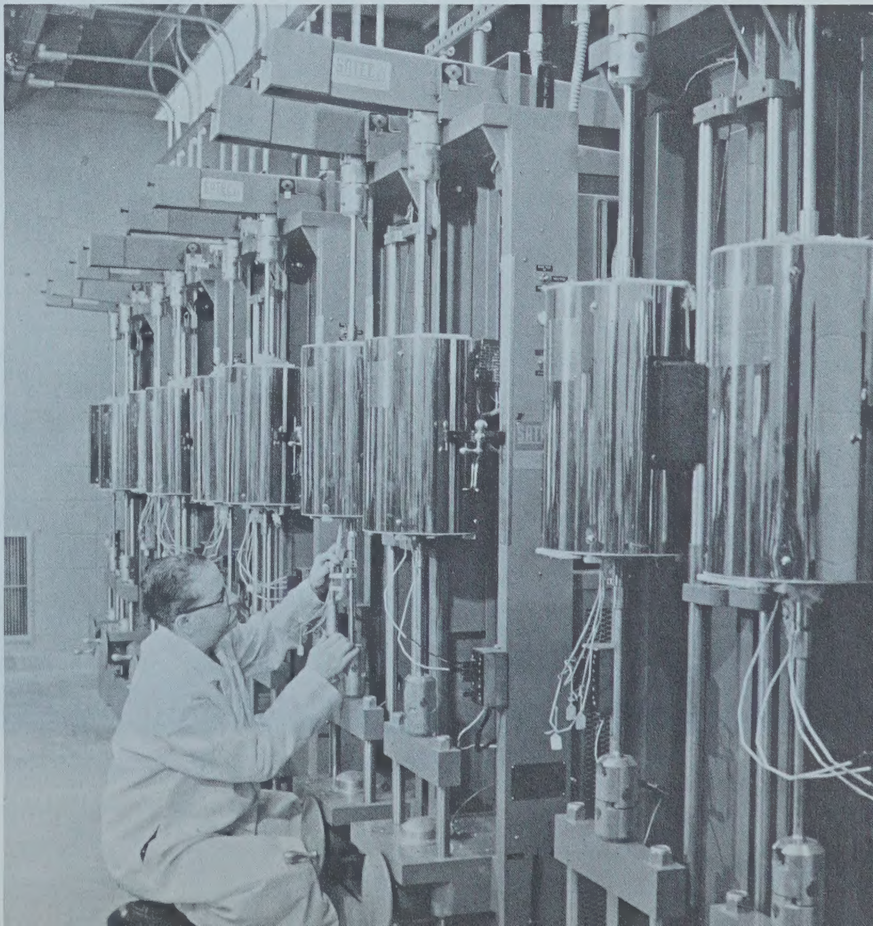
In the coming years, will developments on the scale of ductile iron or maraging steel or high-temperature alloys come out of this laboratory? I wouldn't wager against it. Along with much else today, the process of invention is moving at a furious pace.

We are in what has been called the "Knowledge Explosion." Scholars are reported to be doubling our resources of knowledge every ten years. Nine of



Alloys under development at the laboratory are melted in induction, vacuum, arc or electroslag furnaces, depending upon the basic type of alloy being developed. The Paul D. Merica Laboratory is equipped with every type of furnace used by modern industry.

The Merica Laboratory uses advanced equipment to test the properties and behavior of alloys, for detailed information on these matters is essential to designers and engineers in determining the suitability of a material to a particular application. This equipment, for example, tests resistance to creep and rupture at elevated temperatures.



every ten scientists who ever lived are said to be living and carrying on research today. The most advanced techniques of information control—in scientific libraries, in scientific publishings and in communication—all have great difficulty in coping with the torrent of findings flowing from the laboratories of universities, industry, foundations and government. In our special field of metallurgy, few days go by when one of our research people is not presenting a paper on a new process, on a new alloy, or on a new application. All of this activity is igniting the growth rate of the economy and the opportunities open to the metal industry and our own companies.

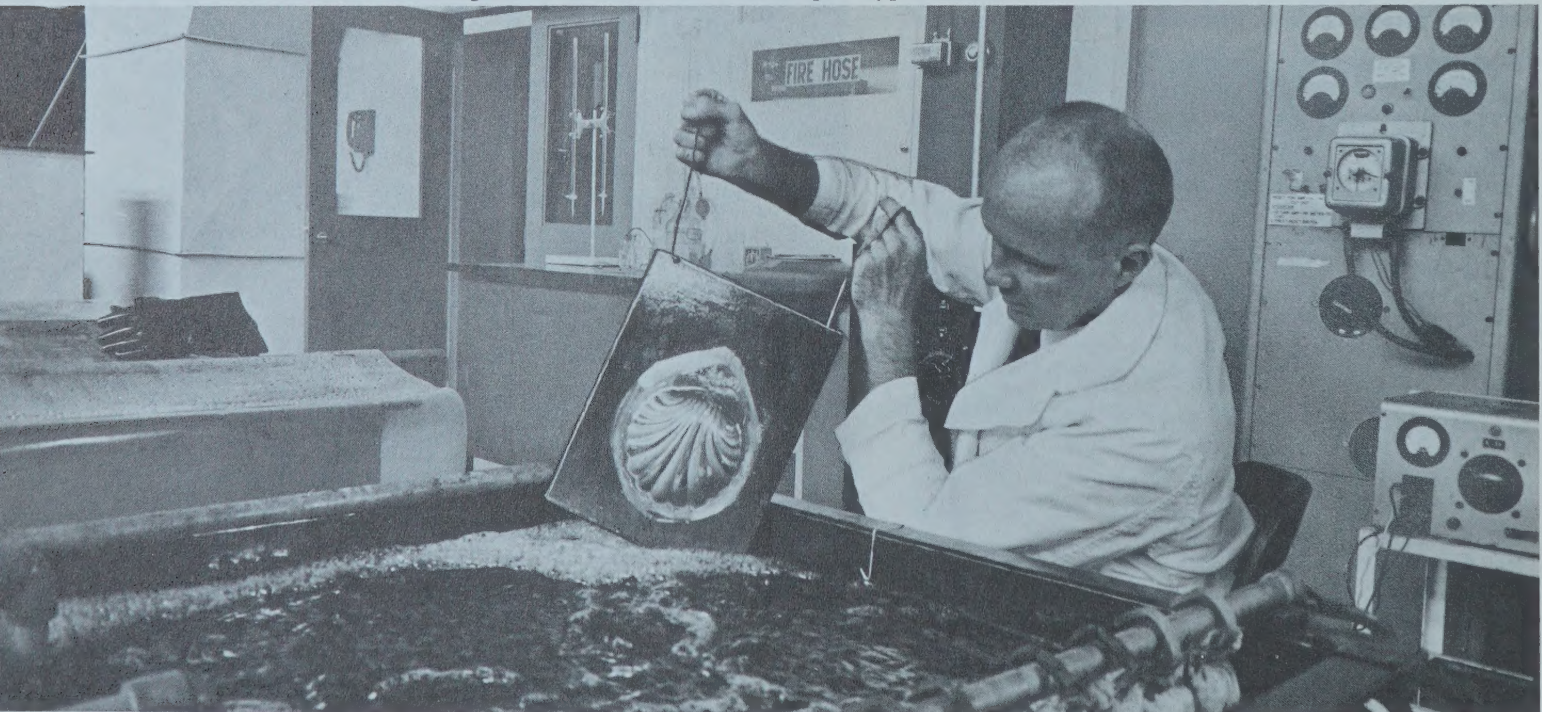
Until quite recently, economic growth rested on several forces: expanding markets, the opening of new natural resources, the growth of population, and the expansion of markets assisted by enterprise and salesmanship. Today there are present all these forces, plus the force of accelerated research. Research is multiplying the choices in the market place—choices closely related to need and function. Research has clearly proved itself one of the finest investments an enterprise can make in behalf of itself or its customers. And competition leaves business no option but to supply new choices to the market place—and to make the best use of research to create them.

In making these comments, I would like to place on the record the large role that universities perform today, not only in developing talent for the laboratories of industry, but in carrying on programs of more basic research which prepare the groundwork for further special investigation. The association of industry and the universities holds out high promise for measurable results in helping create new products, new enterprises and new employment.

I would like to acknowledge the splendid cooperation that the research staffs of our industrial customers have extended to International Nickel. You have encouraged us; you have counseled us in the selection of research programs responsive to your needs, and we hope you will continue to do so. We trust you will continue to take the results of our pilot-plant studies that suggest practical value, to develop them further in the light of your superior knowledge of your industry and finally, to bridge whatever gaps remain between the discovery made and tested in the laboratory and the commercial product ready to face the fire of competition. We will strive to show initiative, imagination and market-mindedness to anticipate and keep pace with your own research and commercial operations.

We hope that all of you, our guests, and your associates will visit this new laboratory often and share some of our own excitement in the possibilities it offers in opening up the unknown. You will always be most welcome.

One of the major areas of research at the new laboratory is concerned with the development of improved decorative and protective coatings, as well as improved anode materials for the plating industry. The laboratory also conducts development work in nickel electroforming. Here, an electroformed nickel prototype is taken from a solution tank.



THIS THIRSTY EARTH

One morning last February a small group of officers and men, armed with crowbars and acetylene torches, headed for two large cast iron pipes leading into the huge U. S. naval base at Guantanamo. The source of the pipes lay beyond a chain-link fence which separates the installation from Cuban territory. The group was led by Rear Admiral John D. Bulkeley, base commander, who had won the Congressional Medal of Honor for helping General Douglas MacArthur escape from Corregidor. The admiral was fighting mad. Earlier, Fidel Castro had cut off water supplies to the base and now he was accusing Admiral Bulkeley of using suction pumps to draw off Cuban water. Bulkeley's reply was, "Hogwash." Guantanamo was using its own water supplied to the base by Navy tankers. He ordered his men to cut the pipes, shutting off Castro's water and shutting up the voluble dictator.

It was obvious that transportation of fresh water to the base from the mainland could be only a temporary measure at best. Some permanent source of fresh water had to be found to keep the base operating at top efficiency.

On February 26, 1964, newspaper headlines proclaimed that a sea-water conversion plant would be removed from its site near San Diego, California, and reconstructed at Guantanamo to produce vitally needed fresh water. If it had not been fully realized before, the importance of the nation's saline water conversion program now became obvious to all. Transfer of the plant from the Department of the Interior's Office of Saline Water to the Department of the Navy took place as part of the Government's urgent program to make the naval base self-sufficient. The unit has been "on stream" producing fresh water at Guantanamo from Caribbean sea water since early last summer.

The conversion of sea water to fresh is not a new idea. For centuries man has known how to do it. The basic concept of boiling water and condensing it is as old as history. But each civilization seems to rediscover problems which have plagued its predecessors, and the problem of water supply is no exception. In fact, the history of man's progress and failure in many

lands parallels his success or defeat in harnessing water.

Man's awareness of the need for pure water is found in his earliest writings. From a Sanskrit text written about 2000 B.C. comes the following: "It is good to keep water in copper vessels, to expose it to sunlight, and to filter it through charcoal." Another ancient text from a later period has the following sound advice: "Impure water should be purified by boiling over a fire, or being heated in the sun, or by dipping a heated iron into it, and then allowed to cool, or it may be purified by filtration through sand and coarse gravel." The Palace of Minos on the island of Crete, also dating from about 2000 B.C., had a system for water conservation. Water, in fact, was at the roots of the civilizations that sprang up on the banks of the Nile, the Tigris and Euphrates, the Indus, the Ganges and the Yangtze Rivers. "After the passion of love," it has been said, "water rights have caused more trouble to the human race than anything else." The importance of water cannot be overemphasized. Its uses are almost infinite—we capture its energy in the form of hydroelectric power, we fish in it for food and sport, we use its surface for recreation and transportation. It quenches our thirst, nurtures our forests and fields. So vital is water to our everyday living, it can mean the difference between economic health or decay and, to a great extent, it governs our standard of living.

And yet today man does not have enough water to meet his needs. It has been estimated that over 200 million urban people do not have access to a water supply that, by modern standards, is ample and safe. And all over, the population is increasing. In the home, on the farm and in industry, the United States, for example, requires well over 300 billion gallons of water per day. This figure is expected to increase to 453 billion gallons per day by 1975.

Recognizing the gravity of the water shortage in the U.S. and, in fact, throughout the world, Congress in 1952 passed the Saline Water Act which authorized the establishment of the Office of Saline Water in the U.S. Department of the Interior to develop practical low-cost means of producing, from sea water or from other saline waters, potable water of a quality suitable for agricultural, industrial and municipal purposes.

As research activities of the Office of Saline Water expanded in the early years, it became apparent that there was a need for a facility where testing of new processes, especially at the pilot-plant level, could be conducted at a seashore location.

In June 1956, through the cooperation of International Nickel, the Office of Saline Water set up an experimental facility at Inco's Harbor Island Corrosion Laboratory in North Carolina. Various pilot plants, including the prototype of the first saline water conversion demonstration plant in the United States—the one million-gallon-per-day plant at Freeport, Texas—were operated there for about seven years. About three years ago, the State of North Carolina donated to the Department of the Interior a 25-acre site at Wrightsville Beach, near the Harbor Island laboratory, for an East Coast water conversion facility. Subsequently, it was decided to also locate the OSW's Research and Development Test Station on the same site. The East Coast conversion facility is one of five large plants located in different areas of the country, each testing a different type of conversion process.

Five Processes

The Freeport, Texas, plant uses a 12-effect long-tube vertical distillation process. In this system, steam is admitted into the first effect or evaporator. The steam fills the space around the outside of the tube bundle, causing part of the sea water to boil as it falls through the tubes. A mixture of vapor and hot brine emerges at the bottom of the evaporator. The hot brine is then pumped into the second evaporator where, under slightly reduced pressure, it again falls through the inside of the tubes. The vapor produced in the first effect flows to the outside of the tube bundle in the second evaporator. Here the vapor is condensed to fresh water by giving up its latent heat of vaporization to the sea water falling through the tubes which again causes part of the water in the tubes to boil. This same process is repeated through all 12 effects of the plant.

The second demonstration plant, formerly located near San Diego and now at Guantanamo, makes use of multistage flash distillation. In this process, sea water is progressively heated under appropriate pressure and then introduced into a large chamber where a lower pressure just below the boiling point of the hot brine is maintained. When the brine enters this chamber, the reduced pressure causes part of the liquid to boil or flash into steam. The remaining brine

Copper-nickel alloy tubing is widely used in saline water conversion processes.

The Research and Development Test Station of the Office of Saline Water, United States Department of the Interior, at Wrightsville Beach, North Carolina. Also located here is one of the five plants established by the OSW.

is passed through a series of similar chambers at successively higher vacuum where the flash process is repeated at progressively lower temperatures.

The progressive heating is accomplished by piping the incoming sea water through the flash chambers, starting at the low-temperature end. In each chamber, the flashed vapor condenses as it gives up its heat to the cooler sea water in the condenser. Final heating of the sea water, before flashing, uses process steam. With this arrangement, about 90 per cent of the heat from this source is re-circulated.

It has long seemed feasible to try methods that remove the salt from water instead of removing the much larger amount of water from salt. A method which utilizes this approach to the problem—known as electrodialysis—has been intensively studied by the Office of Saline Water and by private industry. It is the process that was selected for demonstration in the plant at Webster, South Dakota.

Electrodialysis takes advantage of the fact that salts, when dissolved in water, are present in the form of negatively and positively charged ions. An electrodialysis cell, as utilized in this process, consists of a sandwich of alternating cation and anion permeable membranes. Upon the application of an electric current, the positively charged ions (such as sodium) pass through the cation permeable membranes, and the negatively charged ions (such as chloride) move in the opposite direction and pass through the anion permeable membranes. The water in the center chamber of each membrane sandwich is thus depleted of salt while the water passing through the intervening pairs is enriched.

Since the amount of electricity and current density required is directly proportional to the salt concentration of the water to be treated, this method is not at this time considered economically competitive with other processes for the purification of sea water with its high salt content. Problems are presented also by the presence of organisms suspended in sea water which cause clogging of the membranes. For the demineralization of moderately brackish ground water relatively free of suspended solids, however, it offers attractive possibilities.

The fourth process is a forced-circulation vapor-compression system in which saline water is forced up through a tube bundle in an evaporator. A mixture of vapor and hot brine emerges at the top of the tubes. The vapor is pumped off and compressed, thus raising its temperature. The compression step increases the energy content of the vapor enough for it to be returned to the evaporator to serve as the heating medium. As it condenses, it gives up heat in sufficient amounts to boil more salt water in the tubes. This process—which efficiently uses the heat input and thus saves on fuel costs—was selected for demonstration in a plant at Roswell, New Mexico, which, like the Freeport and Guantanamo units, has a capacity of one million gallons a day.

The demonstration plant at Wrightsville Beach utilizes a freezing process. An ice crystal is pure water. But when sea water freezes, the salt crystals are trapped between the ice crystals. The problem is to separate the salt and ice crystals economically.

Three different freezing processes are under development by the Office of Saline Water. One method flash-evaporates pre-cooled sea water by pumping it into a vacuum chamber where the low pressure causes enough of the heat remaining in the sea water to flash into vapor, with the result that about one-seventh of the sea water freezes. Another method uses a secondary refrigerant, such as butane, in direct contact with the sea water to produce an ice-brine mixture. The third process also uses a secondary refrigerant, but under controlled conditions to produce a much larger ice crystal.

The conversion of salt water by freezing, a relatively new process, is thought by the Office of Saline

UNITED STATES WATER USE **(Daily average, in billions of gallons)**

Year	Total Water Use	Year	Total Water Use
1900	40	1946	168
1910	66	1950	203
1920	92	1955	262
1930	110	1960	312
1940	135	1965	359
1944	188	1970	405
1945	175	1975	453

Source: Office of Saline Water

Water to have considerable potential. Freezing has several inherent advantages over conventional distillation processes, including the lower energy required to freeze sea water as compared to that needed for evaporation.

While these five processes are by no means the only ones by which sea water or brackish water can be converted into fresh water, they are among the most important, and much valuable information is being obtained by testing them at the various sites. Prior to the erection of these units, the most efficient conversion plants were producing fresh water at costs ranging upwards of $1.75 per thousand gallons. While this compares favorably with the cost of conversion in the early 1950's, which ranged upwards of $4.00 per thousand gallons, the cost of conversion in the demonstration plants has been reduced to $1.00–$1.25 per thousand gallons.

A Matter of Materials

One of the most important problems faced by designers of saline water conversion plants is the proper selection of materials to withstand the implacable corrosivity of salt water. This was, of course, one of the reasons the Office of Saline Water set up its initial experimental facility at International Nickel's Harbor Island Corrosion Laboratory. For from that laboratory there has issued forth a steady stream of information on marine corrosion ever since 1935. The knowledge gained through the laboratory's testing programs has been helpful in the selection of the appropriate alloys for the various desalting processes. Indeed, in some cases, it has even led to the development of new alloys.

Research at Harbor Island firmly established the use of 90-10 copper-nickel in heat-exchanger tubes and piping because of its superior resistance to high-velocity effect. It also proved the effectiveness of MONEL* nickel-copper alloys in resisting corrosion and thermal shock which accompanies descaling in some salt water processes. NI-BRAL* nickel-aluminum bronze is another material, developed for use in pumps and other marine applications, used in a number of the desalting processes. And NI-RESIST* corrosion-resisting cast iron and Type 316 nickel stainless steel have been found successful materials for valves, pumps and impellers handling brine.

FIVE PROCESSES AT FIVE OSW PLANTS

Area	Location	Process	Capacity
Gulf Coast	Freeport, Texas	Long-tube vertical multi-effect distillation	1,000,000 gallons per day
West Coast	San Diego, California	Multistage flash distillation	1,000,000 gallons per day
Northern Great Plains	Webster, South Dakota	Electrodialysis (membrane process)	250,000 gallons per day
Arid areas of the Southwest	Roswell, New Mexico	Forced-circulation vapor-compression	1,000,000 gallons per day
East Coast	Wrightsville Beach, North Carolina	Freezing	200,000 gallons per day

Rear Admiral John D. Bulkeley, commander of the U. S. naval base at Guantanamo, supervises the severing of the pipe to Cuba's water supply. The admiral cut the pipe after Castro cut off the water. A saline water conversion plant now provides water for the base.

But the war against corrosion is a never-ending one. Much remains to be learned. Just recently a new series of corrosion tests was undertaken by the Office of Saline Water. These tests, to be conducted cooperatively by Battelle Memorial Institute and International Nickel at Harbor Island, are designed to evaluate the corrosive effects of hot sea water on metals to be used in equipment for conversion plants. Among the materials under study will be steels, copper-nickel and other copper-base alloys, high-nickel alloys and stainless steels. A "dynamic corrosion loop facility" will be erected to simulate conditions found in operational conversion plants. Salt water will be drawn directly from the ocean, heated, and piped through the loop system to various environmental chambers where samples will be placed. Water temperatures in the loop will range from 100 degrees to 400 degrees F, with velocities of two to 40 feet per second. Ways will be sought to predict how metals will perform in contact with water containing various amounts of oxygen. Heat transfer effects also will be studied as well as methods to control the formation of scale on equipment surfaces when sea water is heated.

How long it will take to achieve final mastery of all the problems associated with salt water conversion is anyone's guess. Tremendous strides have already been made, but much work lies ahead. The potential rewards, however, are worth all the effort. For, as President Johnson recently stated, "There is no newer or more vital frontier for any of us than the one we must cross to a lasting abundance of fresh water for all mankind."

*International Nickel Trademark

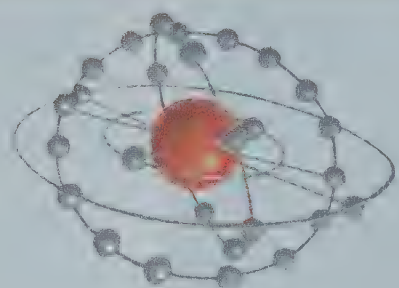
sage saws about science

As a divertissement germane to news elsewhere in this issue of intensification of International Nickel's research activities in the United States, Canada and the United Kingdom, we offer you herewith a sampling from the rich treasury of sage saws about science.

"Science is nothing but trained and organized common sense, differing from the latter only as a veteran may differ from a raw recruit; and its methods differ from those of common sense only as far as the guardsman's cut and thrust differ from the manner in which a savage wields his club."
—Thomas Henry Huxley

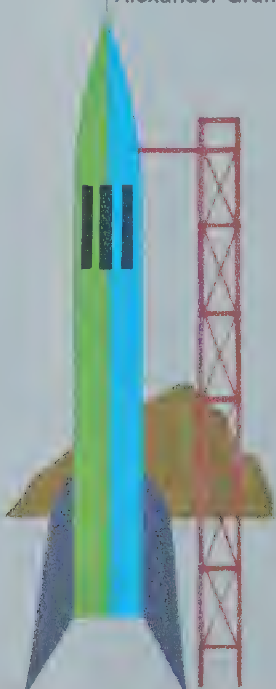
"Science and art belong to the whole world, and before them vanish the barriers of nationality." —Johann Wolfgang von Goethe

"The main difference of modern scientific research from that of the Middle Ages, the secret of its immense success, lies in its collective character, in the fact that every fruitful experiment is published, every new discovery of relationships explained."
—H. G. Wells



"The trail to industrial advancement in modern times is blazed by research."
—Paul D. Merica

"Great discoveries and improvements invariably involve the cooperation of many minds." —Alexander Graham Bell



"If I have ever made any valuable discoveries, it has been owing more to patient attention than to any other talent."
—Sir Isaac Newton

"Research is a high-hat word that scares a lot of people. It needn't be. Essentially it is nothing but a state of mind—a friendly, welcoming attitude toward change."
—Charles F. Kettering

"The best insurance policy for the future of an industry is research, which will help it to foresee future lines of development, to solve its immediate problems, and to improve and cheapen its products."
—Sir Harold Hartley

"The industrial research laboratory has become firmly fixed as a vital and necessary part of the structure of modern technological industry. No major decision regarding the products with which a business deals, whether they be goods or services, is made without its advice." —Frank B. Jewett

Buried deep beneath Saskatchewan's fertile wheatlands is another source of wealth—vast deposits of potash. Saskatchewan, whose principal industry has long been agriculture, has in recent years emerged as a major producer of potash.

WEALTH BENEATH THE WHEATLANDS

By Ronald Anderson, Financial Writer, The Globe and Mail, Toronto

When the Kalium Chemicals Limited potash mine near Regina, Saskatchewan, went into production recently, a good part of the world's fertilizer chemicals industry was, figuratively speaking, standing by to watch the results.

The widespread interest testified to the mine's more than usual significance: it is the world's first potash solution mine and, if it proves to be as successful and economical as the company hopes, it will vastly increase the recoverable reserves of the world's largest deposit of potash, an important ingredient in fertilizers. It could also cause investors elsewhere to recalculate the economics of potash developments in other countries.

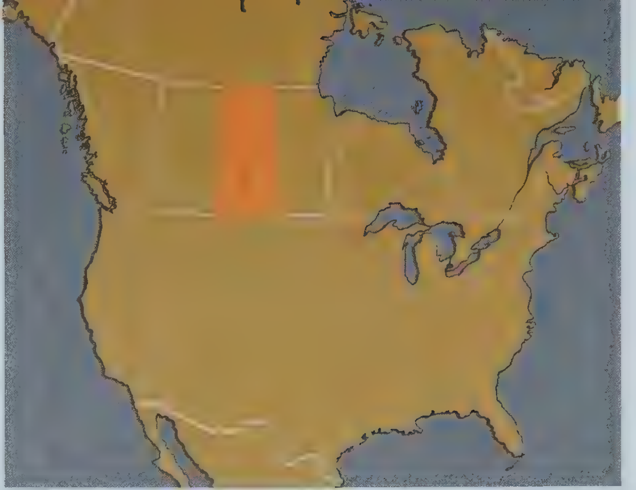
The first potash was man made, literally the ash remaining in a pot after water had been added to hardwood ashes and then boiled dry to leave a white residue. This "pot ash" was a crude form of potassium carbonate and was used principally in the manufacture of soap. The term is now used for all compounds containing potassium, and mines, not hardwood-burning asheries, are the source of the world's potash supply.

Saskatchewan's potash is the residue of an ancient sea that covered large areas of the prairie provinces in the Middle Devonian age more than 300 million years ago. When the sea was cut off from the main ocean body, the water evaporated, precipitating its salts in a great bed. The potash represents the final precipitation of the most soluble materials.

Today, potash deposits lie far below the Saskatchewan wheatlands, at depths ranging from 3,000 to 3,500 feet at the shallow northern edge, to 5,000 feet at Regina and 7,000 feet at Saskatchewan's southern boundary. In places, the deposits have an aggregate depth of 100 feet—an immense depth when it is considered that about 70 feet of sea water must evaporate to yield one foot of potash. The total area of the potash beds has never been calculated. "The thing is so vast that we've just never bothered to measure it," Donald Mode, director of the Mines Branch of the province's Department of Mineral Resources, told an interviewer recently.

The recoverable reserves in the deposits that are less than 3,500 feet from the surface are estimated at 6.4 billion tons of potassium oxide. Virtually all of the land in this shallow deposit area has been blanketed by exploration and development permits taken out by a score of companies, many of them international organizations with potash interests elsewhere.

Kalium Chemicals claims that its solution mining process will increase the recoverable reserves by 40 times and will permit full development of a source of potash that it estimates is adequate to meet the world's requirements, at present rates of consumption, for 8,000 years.



Solution mining is the technique of pumping liquid through bore holes down to underground mineral beds. The liquid dissolves the minerals, and the solution is then brought to the surface where the fluid is removed by evaporation. Solution mining is widely used in the recovery of salt and sulphur, but all attempts to adapt the technique to potash mining have, until now, ended in failure. One of the chief problems is that potash is associated with salt in the deposits, and it is difficult to recover a concentrated solution of potash without dissolving the salt. Previous attempts to recover potash by this means had been too inefficient to be of economic interest. Kalium engineers say they have succeeded in solving this problem, and are able to recover a maximum of potash with relatively little salt. Kalium Chemicals, a joint venture of Pittsburgh Plate Glass Company and Armour & Company, started shipping limited amounts of muriate of potash in October. Full-scale production is scheduled to start in January 1965 at the rate of 600,000 tons a year.

The Kalium mine at Belle Plaine is the third to go into production in Saskatchewan. International Minerals & Chemical Corporation opened a conventional room-and-pillar mine at Esterhazy in 1962. An expansion program is increasing its capacity from 1.2 million to 1.6 million tons. And the Potash Company of America is planning to resume production at its Patience Lake mine near Saskatoon, which had been closed since 1959. Capacity will be 600,000 tons annually.

Capacity Growing

The three mines, if all goes well, will have a combined capacity in 1965 of 2.8 million tons. Meanwhile, IMC is at work constructing a second shaft six miles from its present mine, which will increase potential product capacity by 1968 to four million tons. Kalium expects to have a capacity of one million tons by then. A fourth company, Alwinsal Potash of Canada Ltd., let the main contracts last July for sinking a shaft and building a refinery at Lanigan, 70 miles east of Saskatoon. The $50 million project is planned to be completed in 1968 or 1969, with an initial capacity of one million tons.

Also, United States Borax & Chemical Corp. has announced plans for a $60 million potash mine at Allan, 35 miles southeast of Saskatoon. The company hopes to start production early in 1968 with a capacity of one million tons annually.

On the basis of announced plans, capacity of the Saskatchewan potash industry could reach 7.6 million tons in 1968 or 1969. This would be the equivalent of more than 4.7 million tons of potassium oxide (K_2O), the measurement commonly used for potash. Muriate of potash, the major potassium compound used in fertilizer and the chief product of the Saskatchewan mines, is the equivalent of 62.2 per cent K_2O. Since world potash output in 1963 amounted to about 10.4 million tons of K_2O, and the predicted production in 1965 will be 11.8 million tons, it is expected that the huge volume of new production in Saskatchewan will have a major impact on world markets.

Chemical Week, the authoritative industry magazine, predicted in 1963 that world production of K_2O would total 16,850,000 metric tons in 1970. The rank of the largest producers, the publication said, likely would be: the United States, 3.6 million tons; Canada, 2.7 million; U.S.S.R., 2.4 million; West Germany, 2.1 million; East Germany, two million, and France, 1.7 million tons. The stepped-up plans of Saskatchewan producers, however, suggest that Canada may become the world's biggest producer before 1970.

How It All Started

Development of the Saskatchewan deposits, which now is proceeding so rapidly, almost didn't happen—or at least not until a shortage of potash had developed elsewhere. The prairie deposits had been known to exist since the early 1940's when potash was identified in oil well cores. Later discoveries indicated not only that the reserves were large, but that they were unusually rich; the K_2O content ranges from 25 to 35 per cent, compared with 20 to 25 per cent for the best ores at Carlsbad, New Mexico. (Discovery of the potash salts near Carlsbad in 1925 marked the start of the potash mining industry in North America.)

It was clear from the beginning that development of the Saskatchewan deposits would be enormously costly, technically difficult and risky. This fact imposed certain characteristics on the Saskatchewan industry: development could be undertaken successfully only by large companies; the mines had to be big to justify the high capital costs, and the resulting high volume of production had to find outlets in world markets. The chief cause of difficulties was the Blairmore formation, a 200-foot to 300-foot-thick layer of mucky sand and salt water under very high pressure about 1,500 to 2,000 feet below the surface of the ground. Water must be kept out of a conventional potash mine, since the ore is soluble, and it has proved to be extraordinarily difficult to sink a watertight shaft through the Blairmore.

International Minerals began exploratory work at Esterhazy in 1955. The company needed a new supply of ore, but it knew that some awesome technical problems would have to be overcome to develop a Saskatchewan mine. For a long while it gave careful deliberation to several alternatives: whether to open a mine in Utah, where a discovery had been made; expand its operations in New Mexico, or take a chance on Saskatchewan. Thomas M. Ware, IMC president, told the Investment Dealers' Association of Canada recently that the high grade of the Saskatchewan ore and tax incentives available in Canada finally tipped the balance in favor of the Esterhazy mine. But, he added, the job turned out to be even bigger than had been anticipated.

Two years were lost in trying to get through the Blairmore. The problem finally was solved by adopting a European technique called tubbing. The entire section of the shaft first was frozen into one big mass of ice. Pavement breakers then were used to chip a way through the ice, and a $1 million five-inch-thick cast steel sleeve was put in place and sealed to hold back the water and soil pressures. After the Blairmore, ten more water-bearing formations were encountered, but fortunately they were less difficult. When the 18-foot shaft had been completed to the 3,132-foot level, the cost, merely for the hole in the ground, was $10 million—double the amount that had been expected.

When the mine was started, IMC had simply been looking for an additional source of potash for its U.S. market. "Our thinking had to leap ahead as our shaft costs went up," said Mr. Ware. "Our approach then shifted to world markets and we came to look at our market as 50 per cent United States, 10 per cent Canada and 40 per cent to other continents and foreign countries."

Mr. Ware said the magnitude of the project, in which the company now has an investment of $72.5 million, had forced IMC to transform itself into an international company with global interests.

SOME NOTABLE APPLICATIONS OF NICKEL-CONTAINING MATERIALS AT KALIUM CHEMICALS PLANT

MONEL* alloy 400 cladding on evaporators.

MONEL alloy 400 and 70-30 copper-nickel alloy for tubes and tube sheets in solution heaters.

MONEL alloy 400 for 7-inch-diameter pump shafts, centrifuges, impellers.

NI-RESIST* cast iron for pump bodies and valves.

Type 316 nickel stainless steel for large pumps used in solution mining.

Solution Mining

When Kalium Chemicals decided to develop a potash mine, the idea of solution mining for potash had virtually been abandoned by the industry. It had been tested in Saskatchewan and, over the past 50 years, in Germany, New Mexico and Britain. Always the experiments had failed. The technique, however, promised to be particularly valuable in Saskatchewan if it could be developed successfully. The Blairmore, which had proved such an obstacle to shaft digging, would not stand in the way of sinking bore holes for a solution mine. Also, solution mining would not be limited to shallow deposits. The need for roof support tends to limit the depth of a conventional mine and reduces the amount of ore that can be removed. In solution mining, on the other hand, the entire deposit can be mined because the opening is supported by fluid pressure.

When Kalium became interested in solution mining ten years ago, it first reviewed all previous attempts to solution-mine potash and attempted to determine why they had failed. The company's research staff then looked for ways of avoiding similar pitfalls and tested several theories to find a workable approach. At last, in 1960, a pilot operation was started at the site of the present plant. When the pilot plant was closed in 1963, the company was satisfied that it had learned enough of the answers to go ahead with development of a solution mine.

* International Nickel Trademark

Kalium Chemicals Limited's $50 million plant at Belle Plaine, Saskatchewan, is specially designed for processing potash recovered by solution mining. Full-scale production is scheduled to start in January 1965. About 1,250,000 pounds of nickel—in NI-RESIST corrosion-resisting cast irons, nickel-copper alloys and copper-nickel alloys—are used in the refinery.

The company has, naturally, not disclosed the details of its technique, but the big refinery at Belle Plaine—one of the most massive industrial plants in Western Canada—represents a $50 million bet that the system will work.

The refinery is equipped with a double bank of MONEL alloy 400-clad 130-foot-high evaporators, the largest of their type ever built, to process the large amounts of potash-rich solution drawn up from the beds almost a mile below the plant. Salt removal starts in the evaporators and continues in the 90-foot-diameter thickening tank. Iron and other impurities are removed partly in the thickener and completely in the crystallization process. The result is a white product, in contrast with the pink color of most North American potash. The company believes the purity of its product will be an important competitive advantage, and it has taken pains to prevent iron contamination. "In addition to removing iron and other impurities," H. Vise Miller, sales vice president of Kalium, has said, "we keep them out during processing by the use of MONEL nickel-copper alloy piping and cladding on all vessels."

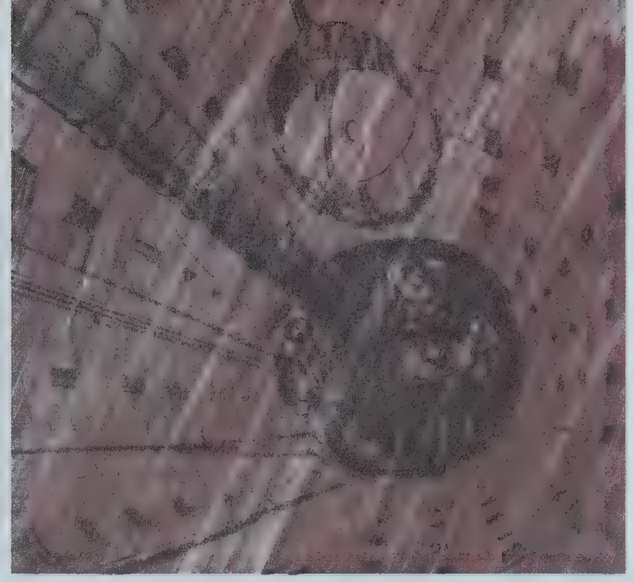
Nickel-containing materials, in fact, are widely used throughout the plant—in valves, circulating pipes and pumps—because they remain unaffected by the corrosive nature of the solution. In total, over one million pounds of nickel—in NI-RESIST corrosion-resisting cast irons, nickel-copper alloys, and copper-nickel alloys—are used in the plant.

Kalium's confidence in its process has attracted renewed interest among other companies in the possibilities of solution mining. At least three companies—Imperial Oil Ltd., Duval Sulphur and Potash, and Southwest Potash—are carrying out experiments in this method of potash recovery.

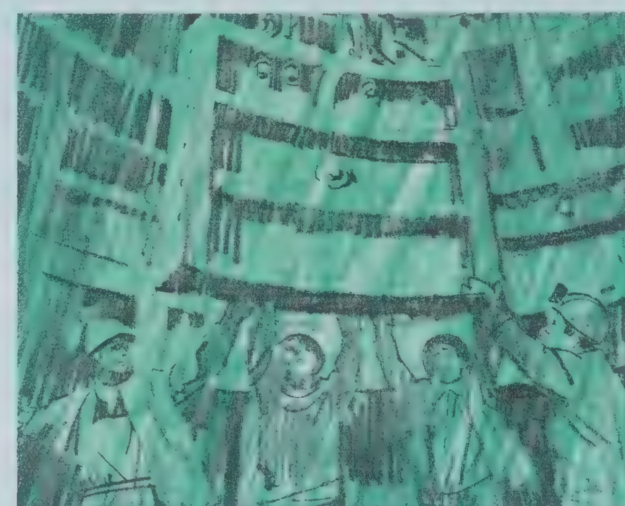
Byron P. Edmonds, manager of mining for Kalium, feels sure that some or all of the companies carrying out pilot operations will be successful and that there eventually will be other solution mining ventures in Saskatchewan on a commercial scale. "But we at Kalium," he said recently, "feel we have a head start and we expect to keep at least a few months ahead of the pack."

Meanwhile, other companies with properties in the shallow-deposit area are stepping up plans for new conventional potash mines. Further extensive development of the Saskatchewan deposits is expected over the next decade.

At present, world potash supply and demand are in approximate balance. Five years from now, it is expected in the industry, a substantial but temporary surplus may develop as a result of expanding production in the United States, the Soviet Union, East and West Germany, Israel and the Congo, as well as in



Penetration of Saskatchewan's Blairmore formation (a layer of mucky sand and salt water about 1,500 to 2,000 feet beneath the surface) to reach the potash deposits below presented a formidable obstacle. In establishing a conventional mine at Esterhazy, International Minerals & Chemical Corporation solved the problem by a European technique called tubbing. In effect, a vertical tunnel was sunk through the Blairmore. Kalium Chemicals Limited took a different tack to overcome the Blairmore obstacle, using the solution mining approach. There was no difficulty in sinking bore holes instead of shafts through the Blairmore.



Saskatchewan. The medium and long-term outlook for potash, however, is considered excellent.

Increasing awareness of the need to replenish the soil nutrients, from the viewpoint of farm economics, and the pressure of expanding world population on limited food supplies have led to a rapid increase in the use of chemical fertilizers since the Second World War.

Fertilizer production has doubled in the past decade to a world total of about 40 million tons a year, of which potash accounts for an estimated 27 per cent. To meet this demand, output of potash has been stepped up from 4.8 million tons of K_2O in 1948 to 10.3 million tons in 1963. To satisfy the continuing annual increase in world demand will require the opening of one new large mine each year, authorities report. By the end of the century, it is predicted that the world's consumption of potash will have tripled to 35 million tons a year.

Trucking Comes of Age

by William G. White
President, Consolidated Freightways, Inc.

About The Author: As a railroad man turned trucker, William G. White is enthusiastic about both modes of transportation and feels each has an important role to play in an efficient over-all transportation system. Mr. White has been president of Consolidated Freightways, Inc. since 1960. Prior to that, he spent 24 years in railroading with the Delaware, Lackawanna and Western Railroad Company. Consolidated Freightways, Inc., with headquarters in San Francisco, operates the largest motor carrier in the United States. A subsidiary, Canadian Freightways Ltd., is a leading trucking firm in Western Canada.

At a Western missile base a giant stainless steel vacuum bottle on wheels delivers a load of liquid hydrogen at a temperature of 423 degrees F below zero. At a nearby construction site another insulated trailer unloads hot asphalt at 400 degrees F above zero. And at a dairy farm a few miles away a set of pneumatic tank trailers blows a load of feed into automatic feeding bins above the herd, while a gleaming tanker departs with a load of fresh milk for the bottling plant.

In Seattle, a trailer load of frozen foods bound for Fairbanks, Alaska, arrives at an Alaska Steamship Company pier. The insulated trailer body is detached from its wheels and lifted aboard ship, becoming in effect a large container. An automatic refrigerating unit is plugged into ship's power and the pre-set temperature will be maintained inside the container until it is transferred at Seward or Anchorage to a flat car of the Alaska Railroad. The refrigerating unit is now plugged into train power for the trip to Fairbanks. There it will be placed on another set of wheels and delivered to a supermarket by the same trucking company that originally loaded it in Idaho.

In San Francisco, a flatbed truck-trailer delivers a load of plywood to a construction site. A few minutes later the driver unrolls a collapsible rubber tank which when filled resembles a huge sausage. On the return trip to the plywood mill he'll be hauling thousands of gallons of liquid glue on the same flatbed, which has been converted into a temporary tank truck.

None of these things was being done a few short years ago, yet today they are commonplace. Each is typical of the endless versatility of the motor truck. They illustrate the trucking industry's characteristic ability to develop new equipment and new techniques wherever there is an economic need or opportunity.

These and other developments also help explain why trucking is second only to agriculture as the largest single source of employment in the United States. There are some 13 million trucks in this country today, providing direct employment for more than 8 million people and responsible for total expenditures currently estimated at $55 billion. This, then, is the trucking industry, an industry which includes literally every person or business that operates a truck.

Regulated Motor Carriers

It was less than 30 years ago that the U.S. Congress took notice of the fledgling motor carrier industry and brought it under Federal regulation as part of the national transportation system. Since the end of World War II trucks have increased their share of total intercity freight revenues from 15 to 46 per cent, about the same amount as that of the railroads. The remainder is divided among water carriers, airways and pipelines. Such a change involves profound changes in our economy and can appropriately be described as a transportation revolution.

There are two broad general categories within the trucking industry: *for-hire trucking*, transportation for compensation of freight that belongs to someone else, and *private carriage*, transportation of one's own goods in one's own trucks or in leased trucks under direct control. Despite its over-all size and importance, for-hire trucking is predominantly composed of relatively small businesses. In 1963, an estimated $8.6 billion in freight revenues were generated by the nearly 17,000 intercity motor carriers reporting to the Interstate Commerce Commission. Of these, only 3,600 were Class I and II carriers with annual revenues exceeding $200,000, and they accounted for approximately 80 per cent of the total revenue. There are, of course, many additional thousands of intrastate and local for-hire carriers which are not under ICC jurisdiction.

Drive and determination were more important than capital in launching a trucking operation 30 or 40 years ago, and many of our largest and most successful companies began with a single truck driven by its owner. In recent years, an increasing number of the industry's larger companies have made the transition from private to public ownership. Today, there are more than 50 publicly held truck lines, compared to only 13 in 1956. This change has been widely accompanied by the development of new managerial concepts and controls. There has also been an accelerating trend of motor carrier mergers and consolidations. The number of carriers reporting to the ICC, for example, has declined from 26,408 in 1940 to 16,835 in 1962. Continuation of this trend seems inevitable, and eventually we may see the number of interstate carriers reduced to a few hundred.

It is safe to predict, however, that such a situation would intensify rather than lessen competition within the industry, a competition which has always been strong and aggressive. And since a similar trend of mergers among the railroads appears certain, it will be a long time before any single motor carrier will approach the size of our larger rail systems in terms of revenue or tons handled.

Most Trucks Privately Owned

Unlike the railroads, however, the trucking industry is not composed entirely or even largely of common carriers. For-hire vehicles account for only 8 per cent of the nation's truck fleet. We must include all privately owned vehicles to get a true picture of the volume of goods transported by truck.

The estimated value of transportation services performed by private trucks in intercity commerce is $11 billion. Intercity trucking involves less than 10 per cent of all trucks, however. When we add to all this the daily work of the other 90 per cent of our

Uninsulated nickel stainless steel tank trailers are widely used for safe and contamination-free hauling of corrosive liquid chemicals. The gleaming trailer shown here was made by Butler Manufacturing Company in Minneapolis.

trucking fleet, trucks of the farm and those at work in our towns and cities stocking our stores or delivering the laundry, we can appreciate the full economic impact of the industry.

The key to this almost universal reliance on the truck, of course, is that, in addition to being a mode of transportation in itself, it is really an extension of all other modes of transportation. Many commodities that move most economically over long distances by rail, water or pipeline still require truck service at either end of the line haul. A familiar example is the tank truck, which eventually delivers virtually all petroleum products no matter how they are originally transported.

Changing Patterns of Transportation

The dramatic changes in freight transportation of the past few decades have been brought about by a number of technological, social and economic developments. A few years ago transportation was largely concerned with the movement of raw materials. While this is still basic, today ever-increasing quantities of manufactured and processed goods are shipped to nationwide markets. Many of these products did not even exist five or ten years ago. New industries and new factories have sprung up to meet the challenge of the electronic age, and they have demanded transportation services suited to their products and their marketing techniques. The rapid growth of the frozen food business, for example, has led to new techniques of insulating trailers, improved mobile refrigerating equipment, including use of liquid carbon dioxide or nitrogen as refrigerants, and the formation of truck lines devoted exclusively to serving this industry.

The population explosion, coupled with the exodus of families from our great cities into suburbia, has also had a tremendous impact. Commerce and industry have joined the move in increasing numbers, until the decentralization of industry has become a major problem for our urban planners.

Vital to this trend and certainly responsible for much of the growth in trucking is the fact that highways have followed the shift of freight business. A recent survey showed that more than 25,000 American communities with no other form of transportation rely entirely on truck service to supply their needs.

Modern technology and design are trending toward long, single-story plants for efficient production lines

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1 This 5,600-gallon, single-compartment insulated tank has a Type 304 nickel stainless steel inner shell and an outer jacket of Type 302 nickel stainless steel. The Heil Company, Milwaukee, designs corrosion-resistant, easy-to-clean nickel stainless steel tank trailers for transporting a wide variety of cargoes, ranging from milk and other foodstuffs to liquid chemical and petroleum products.

2 The familiar tractor and semi-trailer are most commonly used for intercity trucking in the United States and Canada. All transcontinental haulers use this equipment. In the West, three-unit combinations (tractor and two semi-trailers) are becoming increasingly popular, but most Eastern states restrict lengths to 50-feet and do not permit them.

3 Cooperation among various modes of transportation not only strengthens the entire common-carrier industry, but is the only way to develop the efficient national transportation system required by a dynamic economy, William G. White, president of Consolidated Freightways, Inc., notes in his article. An example of intermodal cooperation in action is shown here. It is not uncommon for trailers of motor carriers to share cars with those of railroads in piggyback service.

...the shipment of components to regional plants for final assembly...location of plants or distribution centers in accordance with market studies rather than raw material availability. All of these innovations require more land and flexible transportation. They have meant increasing emphasis on less-than-truckload shipments and fast delivery.

Carriers Must Innovate

Motor carriers have met the new demands by developing new types of equipment and handling systems, often in cooperation with specific customers. Recent innovations include various means of palletizing or unitizing containers of various sizes and types, mechanized and semiautomated freight docks, conveyor sorting systems, simplified documentation and teletype billing. Not every new development is equally useful in all situations, and the successful carrier adapts to meet the particular needs of his operation and his customers.

Understandably, one of my favorite examples of how a trucker's perseverance in filling a need can have wholly unexpected results and lead in fact to an entirely new business is that of our subsidiary, Freightliner Corporation. In this case the need was for a truck that would be shorter and lighter and at the same time have the power to pull maximum loads. The only way to get such equipment at the time was to build it yourself, since the market appeared too small to warrant experiment by major manufacturers. The resulting lightweight cab-over-engine design proved so efficient and popular that the small subsidiary originally established to make it for the parent company has become an important truck manufacturer in less than 15 years.

At the same time, the railroads and water carriers have not lagged in developing more efficient means of moving raw materials. Larger rail cars and supertankers, better motive power and improved handling facilities have all resulted in an ability to transport increased tonnage at less cost. The railroads have also made constructive efforts to improve the movement of manufactured goods through such developments as piggybacking and containerization. Piggyback loadings increased nearly 10 per cent in the first six months of 1964 over the same period of 1963, an indication of the continuing success of these efforts.

Coordination With Other Modes

The trucking industry has grown and come of age

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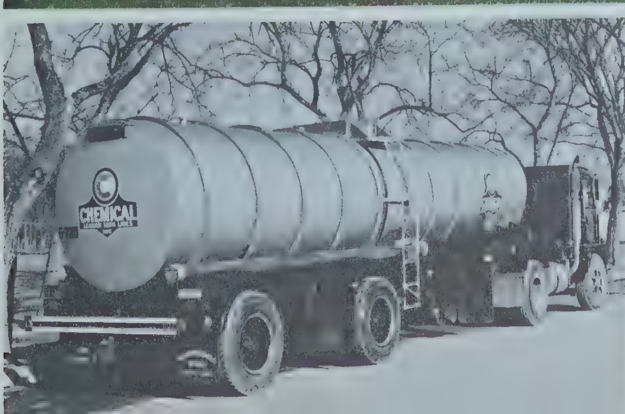


4 In the industrialized and populous areas of Canada, trucking operations are almost identical with those in the United States, the author reports. Flatbed trailers with side racks and tarp such as this one, operated by Canadian Freightways Ltd., are frequent sights on both U.S. and Canadian highways. In the background is the Calgary, Alberta, skyline.

5 The Fruehauf Trailer Division's Volume*Van employs nickel stainless steel in its side panels, front walls, roof bows and side rails. Even when transporting corrosive cargoes, the stainless unit has at least three times the life expectancy of any other material developed for trailer construction, according to Fruehauf.

6 This 5,700-gallon tank, transporting milk in Wisconsin's dairy country, was made by Stainless & Steel Products Co., St. Paul. It is an insulated tank, with nickel stainless steel both inside, to safeguard the milk from contamination, and outside, to keep it looking bright and clean for years to come with a minimum of maintenance.

7 This lightweight nickel stainless steel tank trailer was designed and built under International Nickel's sponsorship. The tank can be easily and quickly cleaned, making it ideal for a great variety of corrosive liquid cargoes. Since the prototype was introduced some two years ago, hundreds of such tanks have been built.

because of its ability to adapt to changing needs. Nowhere is this more apparent than in its willingness to work with other modes of transportation to provide a better or more efficient service to the public. There is no one mode of transportation that is superior in all respects. Each is necessary, and each has a contribution to make. Cooperation among them not only strengthens the entire common-carrier industry, but is the only way to develop the kind of national transportation system needed by our dynamic economy. In my opinion, we have only begun to exploit the possibilities in this direction.

Perhaps the most publicized and familiar of these applications are the trailer-on-flatcar and container-on-ship movements, commonly known as piggyback and fishyback. There is actually nothing new about these concepts, but it is only in recent years that they have achieved prominence. Piggybacking gives the railroads more flexibility and, at the same time, provides opportunities for coordination of service between trucks and rails in a way that recognizes the inherent advantages of each. My own company has piggyback arrangements with nearly 20 railroads and moves thousands of trailers a year by this means.

The Alaska Division of Consolidated Freightways typifies both the scope and versatility of truck service and the benefits of intermodal cooperation. We utilize both ship and rail to transport van containers to Alaska destinations. We also provide a daily overland service from Seattle via the Alaska Highway.

This is a premium service for freight requiring faster delivery than can be achieved by water. Considerable freight for non-highway points in Alaska is exchanged with airlines at Anchorage and Fairbanks.

In addition, the Division operates the longest truck mail haul in the United States, and probably the world, over this same route. Daily overland mail service from Seattle to both Anchorage and Fairbanks, more than 2,500 miles, is maintained at a scheduled 96 hours. Although both commercial and passenger traffic over the Alaska Highway is steadily increasing, there are still 1,500 miles of gravel road to be negotiated, a constant challenge to men and equipment.

Canadian Border No Barrier To Trucks

Trucking in Canada is in most respects similar to that in the United States except for the regulatory situation. Although the Federal government has the authority to regulate motor carriers, it has left this field to the provinces. The result is an absence of rate regulation.

In the industrialized and populous areas, trucking operations are almost identical with those across the border. Canadian and U.S. carriers readily exchange both shipments and equipment at the border, transporting a large volume of international freight.

One of the more interesting aspects of Canadian trucking has been its opportunity to participate in the opening up and development of the Far North, particularly the Northwest. Here, trucks have pushed far beyond railhead to bring in the supplies and equipment needed to sustain the mines, oil fields, construction and other economic activity of this vast and rich area. The experience of our Canadian counterpart, Canadian Freightways Ltd., indicates that the real growth of Canadian trucking has only just begun.

Today, business is placing more emphasis on transport economics than ever before. This applies to each method of transport as well as the entire field of product distribution. It is easy to see why this is true when, from a dollar standpoint alone, transportation accounts for about one-fifth of our gross national product.

I have touched on a few of the newer concepts and techniques of transportation. They may be only an introduction to what lies ahead as new products and new technologies come into being. Change and innovation—whether it is helping to design a portable steel mesh container to improve the protection and handling of small shipments or developing off-highway equipment for 200,000-pound loads—have always been the lifeblood of the trucking industry. We can be certain that trucking, true to its tradition of viability in the past, will not stand still in the future.

HERE TODAY . . .

This experimental gas turbine truck, 96 feet long, with a gross combination weight of 170,000 pounds, is like no other truck in use today. It has been developed by the Ford Motor Company to meet transportation requirements anticipated in the 1970's.

A TRUCK FOR TOMORROW

The Ford Motor Company has unveiled a new long-haul truck which it expects will have a profound influence on the entire trucking industry. This experimental tractor-trailer unit is like no other truck being used today.

A 600-horsepower gas turbine engine is the power plant.

The truck can travel, fully loaded, at speeds of 70 miles per hour for more than nine consecutive hours, or some 600 miles, on a fuel capacity of 280 gallons. It uses ordinary diesel fuel.

The whole unit is 96 feet long and is of "double-bottom" design, incorporating two trailers. Its gross combination weight, including about 50 tons of payload, is 170,000 pounds. The tractor weighs 20,000 pounds and stands 13 feet high—a height equal to that of the trailers.

The spacious cab interior, designed for two-man operation, is seven feet wide and six feet, 3.5 inches high. The cab features lounging and sleeping accommodations, a toilet and sink, a stove and cooking facilities, a refrigerator, a television set, a storage closet, a fold-away table, reading and cove lights, built-in dispensers for liquids, and wall-to-wall carpeting. It is pressurized and is equipped with heating and air conditioning systems.

Easily the most luxuriously appointed piece of workaday machinery of this type ever displayed, the prototype truck recently completed a successful cross-continent tour (from Los Angeles to Boston to Toronto and then to Detroit) of more than 5,000 miles.

The truck will not, however, be mass-produced immediately. This type of vehicle, according to Ford,

is designed to meet the transportation requirements of the 1970's, when a 41,000-mile national superhighway network is scheduled for completion. The network—now more than 41 per cent complete—will link 90 per cent of United States cities with more than 50,000 population.

At that time, Ford predicts, a new era of trucking will begin—with a new breed of truck. It will be possible, for the first time, to plan in terms of truly long-distance non-stop hauling. The road system will have the capacity to accommodate gigantic trucks which will pull trailers at passenger-car speeds. These trucks will travel on the superhighways almost exclusively, making use of terminals near exits to uncouple trailers for local delivery and to pick up new ones.

Why a Gas Turbine?

In developing a truck for such use, Ford engineers believe a gas turbine engine is the logical competitor to the long-established diesel engine. In truck applications, the gas turbine is exhibiting advantages in both initial and operating costs. There are several important reasons for this. Turbines are more efficient when operating at near-constant speed—the general rule in long-distance hauling. Another factor is the difference in installed engine weight. The gas turbine in the Ford experimental truck is approximately one-third the weight of a comparable diesel engine. This makes a difference of some 2,000 pounds of payload.

In addition, a gas turbine engine requires no liquid cooling system and does not "burn" oil or suffer oil contamination. The engine exhibits excellent torque characteristics for heavy vehicle propulsion and has superior cold-start capability. It is characterized by relatively clean exhaust products and exceptionally low vibration and noise levels. Noise tests run 50 feet from the passing truck indicated a noise level of 55 sohns—the same as that of a passenger car. Because the gas turbine features light bearing-loads and no sliding surfaces, longer engine life (up to 500,000 miles) between major overhauls can be expected. All these characteristics are being demonstrated in Ford's experimental truck.

The power plant, called the Ford 705 gas turbine engine, is, of course, the very heart of the unit. The engine is a result of an intensified and extensive research program. Design and development of the engine was initially undertaken as a jointly funded program between the Ford Motor Company and the United States military. While the experimental truck is obviously not a military vehicle, the information and data obtained from testing is to be made available to the Army.

A compact unit, the 600-horsepower engine is only 49 inches long, 44 inches wide, and 38 inches high. Its total weight is only 1,474 pounds. The power plant is, uniquely, two engines in one. Two accessory power takeoffs, capable of delivering 45 horsepower, serve as a fuel-saving standby power plant. These act as a power source for refrigeration machinery or various power assists while, essentially, only half the engine is running. The engine, moreover, consists of five separate assemblies—all of which can be easily removed from the main engine assembly for servicing or replacement. The unit includes a five-speed automatic transmission with a retarder.

The supercharged engine is of the two-stage compression, intercooled, reheat regenerative cycle type. A vital feature, and an important design breakthrough, is the supercharging. This is accomplished by incorporating two stages of compression—a principle considered by turbine engineers as most difficult to develop and apply. Only advanced digital and analog computer techniques, Ford engineers say, made it possible to solve the complex aerodynamic and control problems in this design.

Supercharging is credited with greatly improving turbine performance. It enables the engine to use less air, maintain excellent fuel economy throughout its operating range, and to employ smaller parts running at high speed. One part, the high-pressure compressor turbine wheel, spins at 75,500 rpm—rotating the blade tips at supersonic speeds.

Precision cast of alloy 713LC, this high pressure turbine (right) and compressor wheel play a key role in the performance of Ford's supercharged gas turbine engine. Alloy 713LC is particularly suited to integral precision-casting of integral turbine wheels.

Challenge to Materials

It is obvious that the operating stresses on the mate-

rials chosen for such gas turbine components are necessarily very high. The choice of the best possible materials was, then, of major significance. Significantly, all materials used by Ford are commercially produced and readily available, and most have been successfully used in related applications.

In this field, International Nickel has made at least one substantial contribution. Alloy 713LC, a high nickel alloy recently introduced by International Nickel, is probably one of the most important materials in the development of the Ford 705 gas turbine engine.

Certainly Ford engineers agree that this is so. The alloy has received unqualified praise from Ford design engineers. Without alloy 713LC, they say, successful development of the engine would have been most difficult.

The new alloy is particularly suited to precision-casting of integral turbine wheels—and, as has been pointed out, these are crucial components. It provides excellent ductility and strength in the highly stressed heavy hub sections which operate at relatively low temperatures and also provides the high-temperature strength required for turbine blades. This combination of properties has made possible the design of lightweight high-speed turbine wheels to aid engine efficiency and performance. One-piece investment casting, requiring a minimum of machinery, also helps to cut production costs.

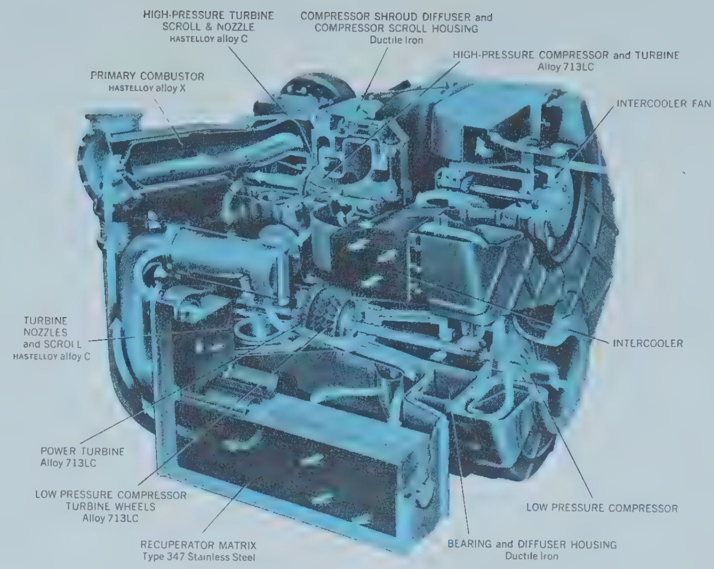
In the Ford 705 gas turbine engines, alloy 713LC castings are used extensively in vital components such as the high pressure turbine rotor and compressor rotor, the first- and second-stage turbine wheels and the power turbine wheel.

These components get severe treatment. The high pressure turbine, for example, not only rotates, at full load, at 75,500 rpm but is also exposed to gas temperatures up to 1,750 degrees F. The low-pressure compressor and turbine operate at 36,600 rpm at full load.

The new alloy is a low-carbon version and a modification of the established alloy 713C. These alloys are patented and produced under license from International Nickel. Alloy 713LC contains 74 per cent nickel, 12 per cent chromium and other alloying elements such as molybdenum, aluminum and columbium. The nominal carbon content is 0.05 per cent and the iron content is kept as low as possible.

Alloy 713LC is not, of course, the only nickel alloy specified. Quite a few nickel alloys are used throughout the gas turbine engine to help provide optimum engine reliability and performance at minimum cost.

HASTELLOY* alloy C, an established material (containing 56 per cent nickel) developed by Union Carbide Corporation, plays a major role. Readily



This cutaway drawing of the Ford 705 gas turbine engine shows some of the critical components of the engine which rely on nickel alloys. One of the most vital materials is alloy 713LC, developed by International Nickel. Without this alloy, Ford engineers say, development of the engine would have been most difficult.

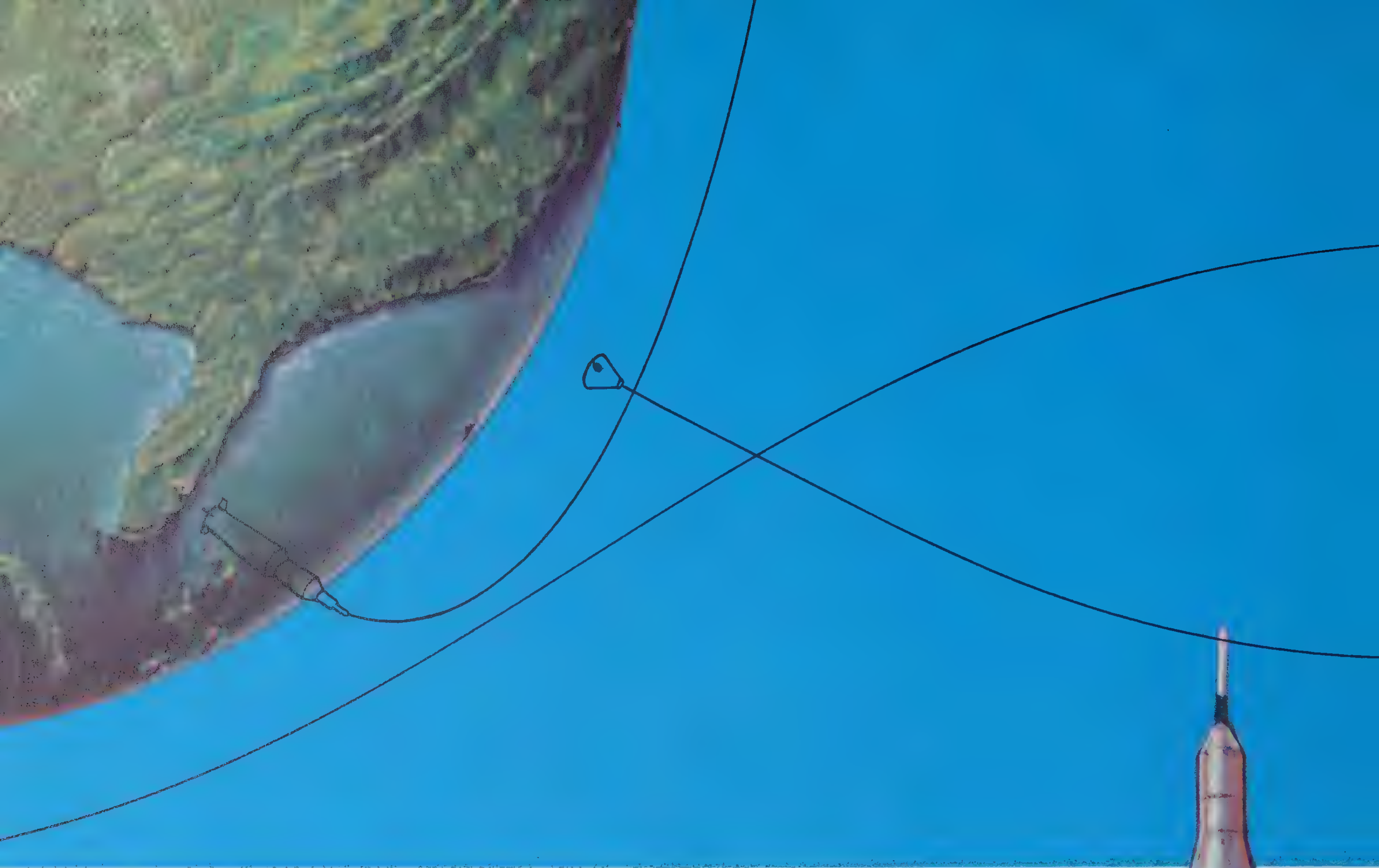
castable, resistant to oxidation and corrosion attack, strong and ductile, HASTELLOY alloy C has gone into many important components of the engine in both cast and wrought form. Components in the high-pressure spool of the engine, such as the turbine nozzle, scroll assembly, turbine wheel shroud, spool diaphragm seal and nozzle ring plate, are made of HASTELLOY alloy C. The alloy is also used in the low-pressure spool assembly for the first- and second-stage turbine nozzles and the first- and second-stage turbine shrouds. The power turbine nozzle, shroud and scroll assembly are also specified in this nickel alloy.

Ductile iron, a ferrous casting material produced under patent license from International Nickel and combining the strength and toughness of steel with the castability of cast iron, is used extensively for cast housings, particularly for those which operate at moderately elevated temperatures or are required to absorb shock loads. Ductile iron is used for housing such assemblies as the high-pressure turbine, the upper and lower diffusers in the low-pressure spool assembly and the power turbine and reduction gear box.

Despite their evident emphasis on engineering details and careful selection of materials, the engineers did not overlook one other most important characteristic of the truck. It is simple to drive. Any truck driver can easily operate it.

The engine is started completely automatically. Basic controls are similar to those of any present-day vehicle. The experimental truck has a footrest and retarder pedals to the left of the driver, and a brake and accelerator pedal to the right. The driver uses an electric gear selector switch to shift gears to the one desired, and uses the retarder and brake pedals to slow down and stop.

*Trademark, Union Carbide Corporation

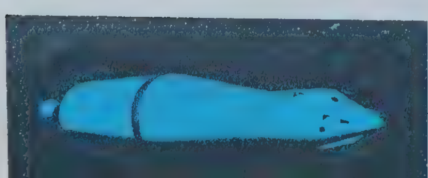


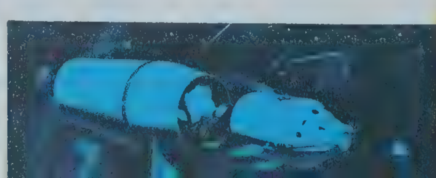
APOLLO MIDWAY TOWARD APOGEE

The hands of the dial point to zero; a button is pressed. Within the towering Saturn V rocket, a gas generator ignites, its exhaust directed against the blades of a turbine wheel. Inertia overcome, the wheel turns, and with it the shaft and blades of a twin-stage, double-volute turbopump. Turning at 6,000 revolutions per minute, the pump draws from cavernous storage tanks one ton per second of special kerosene fuel and two tons per second of liquid oxygen to feed the thrust chambers of five powerful F-1 rocket engines. In an instant, a flicker of light grows to a blinding 5,000-degree F flame; there is a shattering roar, and seven million pounds of thrust lift the 3,000-ton rocket from its pad. The four billion-year bond of earth has been broken and man has begun his first lunar journey.

If all goes according to schedule, this momentous event may occur sometime in 1969, some eight years after President John F. Kennedy established the moon trip as a na-

Docking and third-stage separation of Saturn V, the rocket which will send the Apollo spacecraft to the moon.





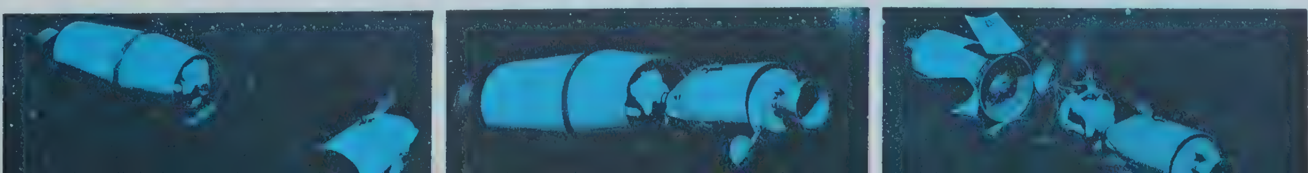
tional objective for this decade and 43 years after Robert H. Goddard, the American rocket pioneer, fired the first liquid-fuel rocket.

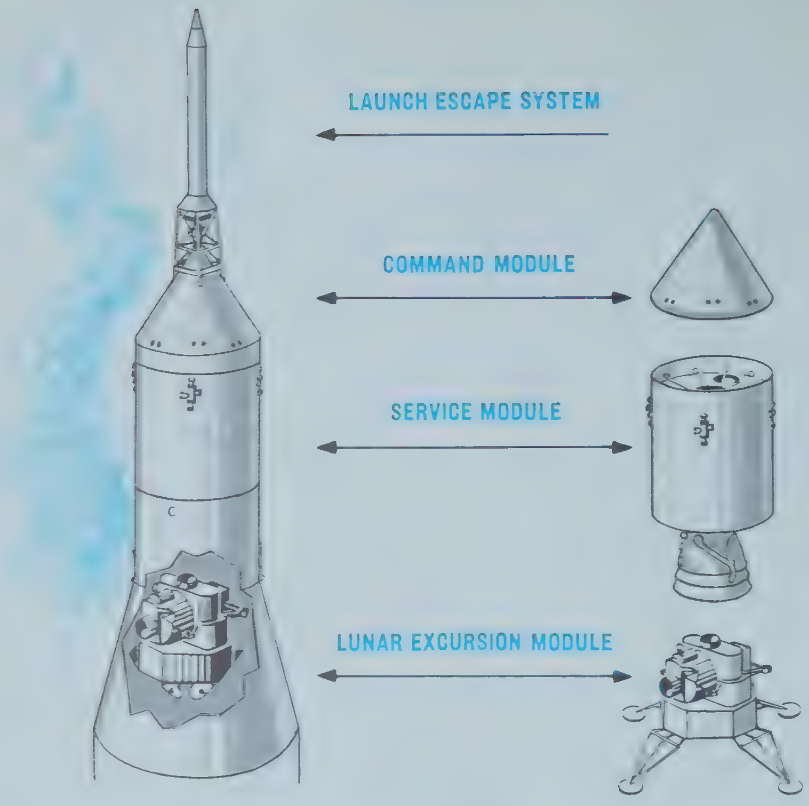
Project Apollo—the incredibly complex undertaking of placing man on the moon and returning him safely to earth—is well advanced. The science fiction of yesterday is about to become reality. The moon is within man's grasp; the flight plan has been logged. Close-up photographs of the moon taken by Ranger VII last summer have been interpreted by most experts as confirming general scientific belief that the lunar surface is firm enough to support men and their space vehicles. The project has reached the stage where astronauts are being trained in lunar craft maneuvers. Twenty-seven men are at present in astronaut training. From this number, three will be chosen to make the initial round trip to the moon.

Project Apollo is far and away the biggest and most complex of the current manned space flight projects. It would hardly be an exaggeration to say that practically the entire industrial, scientific and technological capability of the United States has been or will be, in one way or another, called upon to help attain the goal. It is expected that 20,000 companies, large and small, and 300,000 people will have participated in Project Apollo by its completion. The Apollo spacecraft alone, exclusive of the Saturn V rocket which will send it to the moon, will represent the contributions of thousands of subcontractors.

It is impossible to avoid superlatives in describing the project. The 3,000-ton rocket will be assembled in a specially built structure, the world's largest building, by volume, and it will be transported to its launch pad on that big day to come by one of the world's largest ground vehicles. And here's still another superlative. Representing an expenditure that has been estimated at $20 billion, it is believed to be the costliest single project ever undertaken by the United States. Even from a purely monetary viewpoint, every U.S. citizen has a huge stake in its success.

The culmination of all of this effort will be an eight-day, 500,000-mile trip. Briefly, here are the travel arrangements for that historic journey. The Apollo spacecraft will be launched by Saturn V, first into earth orbit and then on to the moon. Saturn V, the most powerful rocket package under continuous development in the world, consists of three stages, designated in their order of fire as S-IC, S-II and S-IVB. It is the job of S-IC to lift the entire 3,000-ton, 360-foot-tall package from the launching pad and





accelerate it to a high speed. In approximately two and a half minutes, S-IC will have exhausted its fuel supply, and will be automatically jettisoned. At the same time, the launch escape system, which would be used to carry the astronauts away from the package in case of malfunction, will be jettisoned. Then, S-II will fire and hurl the package toward earth orbit. Nine and one-half minutes after lift-off, S-II will also have exhausted its fuel supply and be jettisoned, and the S-IVB will take over, placing itself and the spacecraft in earth orbit. During earth orbit, all systems will be thoroughly checked to insure proper functioning; then S-IVB will re-ignite to send the Apollo spacecraft on to the moon. All the preceding activity will occur within 90 minutes after lift-off.

At the head of the S-IVB rocket will be the spacecraft, consisting of the Command Module (C/M), which has housed the astronauts thus far during the voyage; the Service Module (S/M), containing an engine, propellant and the power supply, and the Lunar Excursion Module (LEM), the two-part "bug" which will land on the moon. En route to the moon, an adapter between the S/M-C/M assembly and LEM will be automatically removed. The S/M and C/M will then detach as a unit from LEM, turn 180 degrees by means of small control rockets, and re-attach to LEM. This maneuver will be executed so that two of the three astronauts can enter LEM from the C/M. When the operation is completed, the S-IVB rocket will be jettisoned. The engine of the S/M is now pointing toward the moon and will be used to slow the spacecraft's speed, thus avoiding an overshoot and, at the same time, enabling the spacecraft to achieve a 100-mile-high circular lunar orbit.

LEM is then separated from the Command Module, which remains in orbit with one astronaut aboard. LEM's engine is briefly ignited, causing the module to establish an elliptical orbit which will take it to within 10 miles of the moon's surface. When LEM is at this altitude, its engine will again ignite to thrust the module out of orbit for descent to the lunar surface.

The astronauts will remain on the moon for a period of time ranging from four to forty-four hours depending upon several factors, including the number of orbits made around the earth en route to the moon, as well as advances between now and 1969 in life-support equipment. During their stay on the moon, the astronauts will collect samples of rocks and dust, set up scientific instruments to gather a variety of data and make visual observations of their lunar environment.

At departure time the astronauts will board LEM and ignite its ascent engine. LEM will detach from its landing stage which will serve as a launching pad. Upon entering an elliptical orbit around the moon, LEM will, automatically and by astronaut control, close in on and attach to the Command Module. The two astronauts will then rejoin their companion in the Command Module, which will detach from LEM. The latter will be left in lunar orbit while the Command Module, powered by the Service Module's engines, will speed back to earth.

When the final flight pattern has been attained, the Service Module will separate from the C/M. The Command Module will re-enter the earth's atmosphere and be gently parachuted to earth. The Service Module will either become a spectacular meteor as it re-enters the atmosphere or remain in space, aimlessly circling the earth.

Unprecedented Obstacles

Quite obviously the obstacles presented by this daring voyage into the unknown will be greater than ever before encountered. Factors such as temperature extremes, vibration, noise, meteor impact and various types of radiation will demand the best of materials and technology. Fortunately, the best of both is available. Numbered among the fine materials, selected for the lunar voyage after careful study and research, is nickel in its pure and alloyed forms. From the thrust chamber of the F-1 engines to the tip of the launch escape system...from fuel pumps to electrical storage batteries...nickel will be present to impart strength, resistance to heat, cold and corrosion, and other vital physical and chemical properties to help insure a safe, sound and successful trip.

There are hundreds of components in the Saturn V and Apollo spacecraft that rely on nickel materials, principally nickel-containing alloys. The high-

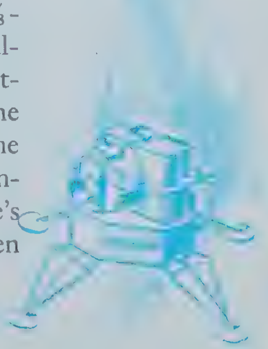
NICKEL IN PROJECT APOLLO

Below is a listing of some of the components of the Saturn V and Apollo spacecraft where nickel is used as an alloying element. Far from complete, the tabulation will nevertheless give an idea of the tremendous range of tasks confronting this versatile element.

A sintered nickel powder electrode for a fuel cell power plant is inspected with a binocular microscope. A fuel cell power plant of the type used in Apollo is made up of many individual cells, each consisting of two electrodes such as the dish-like object shown here. The electrodes are separated by an electrolyte—potassium hydroxide. Hydrogen is fed to one electrode, oxygen to the other. Electrical energy is produced by a chemical reaction between hydrogen and oxygen in the presence of the electrolyte. A by-product of this reaction is H_2O, pure drinking water which will be used by the astronauts during the voyage to the moon and back.

	PART	NICKEL MATERIAL
THE F-1 ROCKET ENGINE	Tube bundles in thrust chamber	Nickel-chromium alloy X-750
	Turbine disc and manifold for fuel pump power	A nickel-chromium alloy
	Turbine blades	Alloy 713C (a nickel-chromium alloy)
	Gas generator components	Type 347 nickel stainless steel
	Fuel injector head and dome	Alloy X-750
	Engine seals and thrust chamber support bands	Alloy X-750
	LOX inductor	Nickel-copper alloy K-500
THE J-2 ROCKET ENGINE	(The J-2 engine develops 200,000 pounds of thrust. Five J-2 engines are used in the S-II stage of Saturn V; one is used in the S-IVB stage.)	
	Thrust chamber tubing	Type 347 nickel stainless steel
	Injector head and dome	Nickel-chromium alloy 718
	Turbine disc and blades	A cobalt-chromium-molybdenum-nickel alloy
	Fuel ducting	Alloy 718
	Gas generator	Type 321 nickel stainless steel
THE S-IC STAGE ROCKET CASING	Tubing	Austenitic nickel stainless steel
	Hydraulic and pneumatic pressurization lines	Type 321 and Type 304L nickel stainless steels
	Actuation systems	Type 321 and Type 304L nickel stainless steels
	Flexible bellows on fuel lines, expansion joints	A nickel-chromium-molybdenum alloy
COMMAND MODULE	Skin structure	A precipitation hardenable nickel stainless steel
	Pressure vessels	Alloy 718
	Various fasteners	An iron-nickel-chromium alloy
	LOX bottle	Alloy 718
	Brazed honeycomb insulation (structural heat shield)	A precipitation hardenable nickel stainless steel
	Reaction control system, including valves, injector domes and outside can of rockets	Type 321 and Type 347 nickel stainless steels
LAUNCH ESCAPE SYSTEM	Nose cone	A nickel-chromium alloy
	Escape motor case	An iron-nickel alloy
	Interstage structure	Type 301 nickel stainless steel
SERVICE MODULE	LOX bottle	Alloy 718
	Reaction control system valving and piping to 300 psi pressure	Type 347 nickel stainless steel
LUNAR EXCURSION MODULE	Fuel tanks	An iron-nickel alloy
	Fuel lines	Type 304L nickel stainless steel
	Valving in fuel system	Type 347 nickel stainless steel
	Descent engine skirt	A nickel-iron-cobalt alloy

strength properties of nickel, under conditions ranging from ultra-high temperatures to cryogenic cold, are perhaps best exemplified in the F-1 engines of the S-IC stage. As indicated, five F-1 engines are used during lift-off, and will power the Saturn V and the Apollo spacecraft to an altitude of 40 miles. Gases in the F-1's 20-foot-long, 12-foot-diameter thrust chamber reach 5,000 degrees F, nearly half the temperature of the sun's surface. Since no present alloy is capable of withstanding such heat for any length of time, designers of the F-1 provided a built-in regenerative cooling system that lowers the temperature of the thrust-chamber walls to 1,000 degrees—well within the safety limits of the wall material. The principle of operation of the cooling system is not unlike that which is used in the automobile engine. However, instead of using water to carry away heat, the F-1 chamber uses the engine's special kerosene fuel. The fuel is circulated from the tank through 1⅛-inch-diameter tubes that are joined together by palladium-containing brazing alloys to form the thrust-chamber wall. By circulating the fuel through the tubes, the chamber walls are cooled. At the same time, the fuel is heated, thus making it more combustible when it passes from the tubes to the engine's injector head where it is mixed with liquid oxygen



and burned.

The tubular-type wall does more than circulate kerosene fuel. Its design also meets the requirements for containing the tremendous pressures generated by an engine that develops 1,500,000 pounds of thrust. An intensive study for a tube material that would withstand both the temperature and pressures resulted in the selection of INCONEL alloy X-750, a nickel-chromium alloy developed by International Nickel for high-temperature service under corrosive operating conditions. The high-strength properties of this alloy permit design of thinner wall-section tubes, resulting in a minimum of weight. Thinner tubes also provide a lower wall temperature on the inside of the chamber, even though their thermal conductivity is lower than that of some other materials considered.

Another notable high-temperature application of nickel alloys is in the turbine wheel and its manifold —the power plant for the fuel pumps. As the turbine wheel revolves at 6,000 revolutions per minute, it is subjected to cyclic temperatures up to 1,800 degrees F, as well as to centrifugal strains. For the turbine wheel (which delivers 60,000 horsepower) and manifold, a nickel-chromium alloy is used to provide adequate strength for high operating pressures and elevated temperatures. Hundreds of tests of the F-1 turbopump assembly have successfully demonstrated the soundness of the design principles and the materials used.

It is in the handling of liquid oxygen (LOX) that nickel demonstrates its superior strength at cryogenic temperatures. For example, the LOX dome of the thrust chamber, which provides distribution of the liquid oxygen to all areas of the injector and thence to the firing chamber, is made of an alloy containing a high percentage of nickel. This material, INCONEL alloy X-750, was selected for reasons over and above its cryogenic strength. The dome is the focal point for the transmission of the thrust of the F-1 through the gimbal bearings to the vehicle. In other words, it is the point where the 1,500,000-pound thrust of each engine meets its apportioned weight of the 6,000,000-pound Saturn V and Apollo spacecraft.

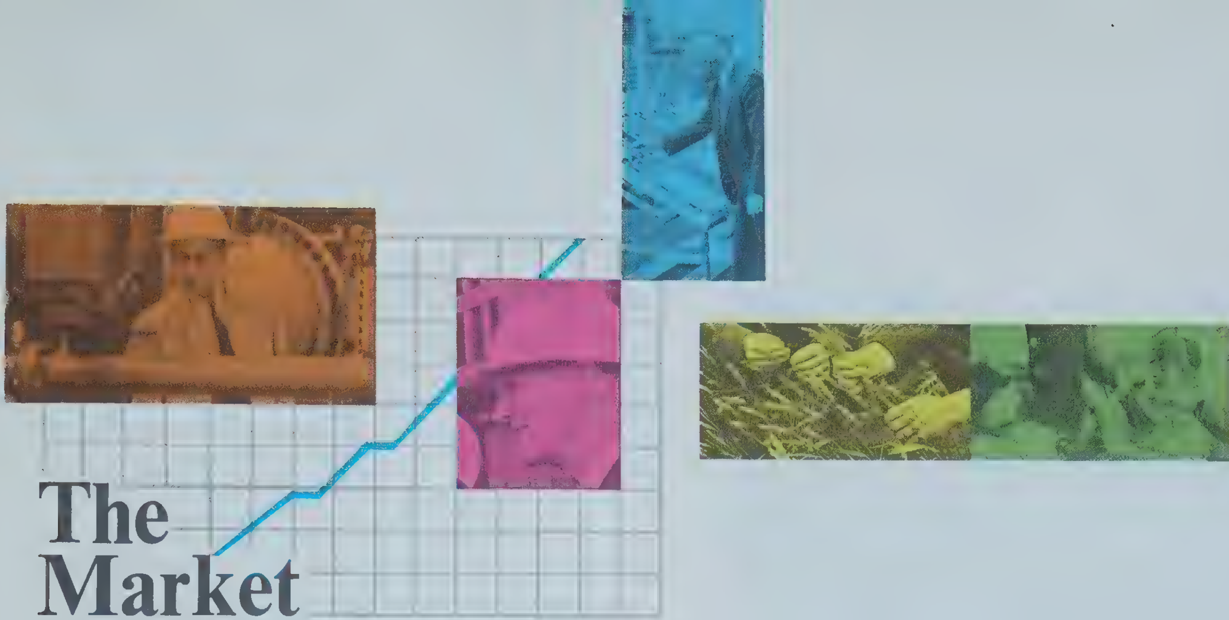
Nickel alloyed with iron, chromium, and a variety of other metals is used in numerous other applications in the F-1 engine. Among these are engine seals; thrust-chamber support bands; the forged dome atop the combustion chamber; the turbine housing for the fuel pumps; piping; duct work, and in fasteners, bolts and tubing.

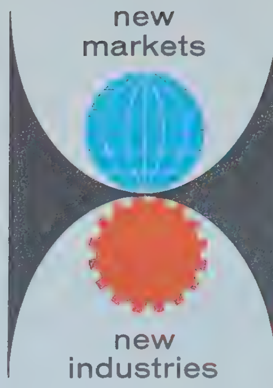
Aside from its alloys, nickel will also be present in other forms on man's first trip to the moon. To cite one example, the fuel cell power plants, which will provide from 500 to 2,000 watts of electricity for the spacecraft, will have pure nickel electrodes. The porous electrodes, made from nickel powder, are similar to those used in the nickel-cadmium batteries that have given us portable power for scores of household appliances.

On the ground, as well as aloft, nickel finds many applications in Project Apollo, so many, indeed, that they will be the subject of a subsequent article. Huge tanks and pipelines for the storage and transport of liquid oxygen and liquid hydrogen, for example, use nickel-containing cryogenic materials. Nickel alloy steels are used in the launching tower for Saturn V. And various apparatus for testing equipment and systems, such as the 15-ton stainless steel vacuum chamber containing a simulated Apollo crew compartment, rely on alloys containing nickel to contribute strength under tremendous atmospheric pressures. A project as ambitious as Apollo requires, as our next article will show, an awesomely intricate ground-support system.

Vast and complex as it is, however, Project Apollo may one day be considered merely a sort of Columbus' voyage in the history of space exploration. In future years, when man steps across even greater distances than those separating earth from the moon, larger and exceedingly more sophisticated spaceships will be under his command. Solid and liquid fuels may be replaced by atomic energy and perhaps even the energy of light. It is difficult to visualize what shape these spaceships will take or the boundaries of their probes. Of one thing, perhaps, we can be relatively certain. Their designers and builders will still be using the basic elements that we know today, and nickel will still be helping to blaze trails through space.

An Apollo engineering test Command Module is hoisted from the Gulf of Mexico to determine its stability in water. The heat shield, which will entirely cover the Command Module that makes the lunar trip, will be constructed of 50 panels of brazed nickel stainless steel, covered by an ablative material. When the Command Module re-enters the earth's atmosphere, the ablative material will burn off, thus dissipating most of the 5,000-degree F heat generated by the module's high speed.





The Market Makers

"Every effort is being made to introduce nickel into new fields and to extend its use in old lines...The results have been gratifying; about 12,000 tons of nickel steel rails, 3¼ per cent nickel, have been purchased by the American railways...Seamless drawn tubes, containing a high percentage of nickel, have been successfully manufactured...it is quite probable that within a very short time nickel steel will be largely used in bridge construction."

These words and the concept they articulate—expansion of the market for *nickel* by creating and broadening markets for *nickel-containing materials*—are as old as International Nickel. Indeed, the quotation comes from the organization's very first annual report, for the year 1902.

The idea of a primary producer selling his product by promoting the sale of others' end products was a daring one in 1902. It is still—over 60 years later—not a run-of-the-mine approach to marketing by a mining company.

When that first annual report was published, only about 10 million pounds of nickel were marketed annually. At that time nickel was used primarily for plating and in coins. Today, over 600 million pounds of nickel are used each year in stainless and alloy steels, plating, ferrous and non-ferrous foundry products and in more than 3,000 different alloys.

Technological advances in all industries have, of course, greatly contributed to this impressive growth in nickel consumption over the years. So, too, has scientific research on nickel and its alloys. From metallurgical laboratories have come a continuing stream of nickel-containing products for industrial and consumer-goods applications.

Less heralded, perhaps, than the contributions of the research scientists have been those of the market makers. At International Nickel, it is their job to develop new applications in which nickel-containing materials will offer economic advantages over other materials either in terms of lower initial costs or long-term savings resulting from longer life, less maintenance or a more pleasing appearance and, hence, greater sales appeal. But their job does not stop there. They also assist industry in applying nickel-containing materials to both new and established products, and, finally, they often help promote the sale of the products in the market place.

Making markets for nickel is a bit different from making markets for canned soups or automobiles. The ultimate consumer is in most instances many times removed from the nickel industry, for nickel reaches the consumer market not as a pound of nickel but as an integral part of a product in which it has very often completely lost its identity. Thus, there are many "customers": the *immediate customer* (the company purchasing nickel to make an alloy steel or to plate bumpers or whatever); *his customer* (the manufacturer who purchases the nickel-containing material), and occasionally even *his customer's customer* (the retailer who sells the products made of this material). International Nickel's market development program is, then, not one of assistance merely to direct customers but to all nickel users.

Global in Scope

This program of building nickel markets by assisting nickel users with advice on materials, technical help and promotional support is worldwide in scope. International Nickel and its distributors have offices and technical personnel in key industrial areas from New York to Tokyo, from Melbourne to Dusseldorf, from Toronto to Sao Paulo. Whether he is in Chicago or Bombay, Zurich or Johannesburg, the market development man is a specialist with a high degree of expertise.

Wherever possible, market development personnel

International Nickel's application engineers, specialists in every industry which is served by nickel, meet regularly to discuss market development strategy and to review potential markets for nickel-containing materials. They work closely with industry and act as advisers on technical and marketing problems.

in a geographic area or country work as an autonomous department. Their activities, however, are coordinated with the entire organization's efforts. For example, in the United States—the world's biggest market for nickel—such duties are carried out by over 50 men in the market development department.

Spearheading its activities is a group of application engineers in the New York office. Each application engineer is a member of a team which specializes in and is directly responsible for guiding and directing market development activity in a particular industry. Industries receiving special attention include aircraft and missiles; architecture; consumer products; power; chemical; electronic; passenger automotive; construction and machinery; shipbuilding and marine; petroleum and the various process industries.

The application engineer's duties may include help to a nickel user's marketing and technical staff; providing engineering information to a local or national technical society; giving advice—including engineering specifications and data—to new-product manufacturers, or providing marketing information for a new or existing product line.

He may uncover opportunities for the laboratory development of a new nickel material, a new and more economical manufacturing process or even a new product. Or perhaps the result of the application engineer's assistance may be a better use for a nickel-containing product or a better, cost-saving production technique and thus a better, cheaper product for the final consumer.

Men in the Field

The market development department in the United States, to use this market area as an example, also has personnel working out of eleven district offices in key industrial areas. These offices represent International Nickel locally in almost all matters concerning nickel in their respective geographical areas.

The district office representative has a broad knowledge of materials and industries and his interests range over the whole industrial complex in his locality. He serves nickel users by providing technical and marketing help. He acts, in many cases, as a source of ideas for product and market development.

There is an uninterrupted flow of information and ideas between district office representatives and application engineers. The combined talents of the department help to determine marketing plans for immediate action, plans for the next five, 10 or 15 years and to propose marketing objectives even farther into the future. All major market-development activities, however, are reviewed and approved by a market development committee headed by the manager of the market development department and composed of representatives from various other departments.

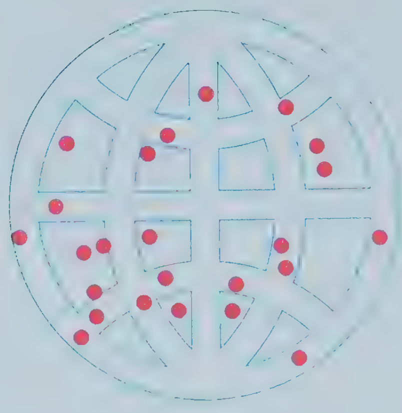
The primary responsibilities of the committee are to guide the activity through which existing nickel-containing products will achieve new and greater markets by way of serving the consumer better. At the same time, in such a market-oriented atmosphere, the ideas which help to produce new products to meet new needs are also born. Furthermore, participation in the committee by various departments helps to foster a market and customer orientation on the part of personnel throughout the entire organization.

Priority marketing plans—there are some 100 of these at the present time, all calculated to increase nickel use—receive immediate attention. Before each one is formally adopted as a marketing objective, however, before application engineers, district office men and all pertinent departments proceed to implement the plan, the groundwork is carefully laid through market research and analysis. The market is evaluated, the materials used are studied and the competitive position of likely nickel-containing materials is assessed. Only when it is concluded that a nickel material may prove advantageous is a plan formulated. If the plan involves a new material or a new product design, essential technical data, based on product research, are prepared.

Armed with such pertinent information, market development personnel can offer a particular manufacturing industry data based on market research, technical help, and cooperation in publicity and advertising.

Market development personnel continually work as well on smaller-scale projects which do not require such extended effort but which are important nevertheless. Marketing and technical aid to users

and potential users of nickel is always available. The emphasis of this assistance is always on better ways to produce better nickel-containing products that will also, in the long run, bring a better profit for the producer and a better buy for the consumer.



Marketing Plans

One example of success with the marketing plan approach is the development and acceptance of 9 per cent nickel steel. This steel is now widely used for containers for storing and transporting liquefied gases under pressure at extremely low (cryogenic) temperatures.

The need and potential market for such a product were predicted many years ago as the economic advantages of storing and shipping gas in liquid form became evident. In the development of the new science of cryogenics, it became apparent that a large potential market existed for an economical material of exceptional toughness and strength at temperatures as low as –320 degrees F. Nine per cent nickel steel, a product of International Nickel's research laboratories, met these criteria. Welding and fabricating techniques for the steel were perfected and research data on the alloy and the right to make it were turned over to steel producers.

Efforts did not stop there, however. With the cooperation of a major steel producer and a fabricator, a dramatic demonstration of the properties of large cryogenic containers made of 9 per cent nickel steel was presented before potential users and code-body factors. They were given performance records, cost data, and information on the best ways to employ the new steel to attain long-range economies. As a result, the steel was approved for use by the ASME in the as-welded condition, without stress relieving, down to –320 degrees F and it has gained wide use in handling liquefied gases in the United States and Europe.

Another example is the development of a lightweight nickel stainless steel tank trailer. In this case, however, no new alloy had to be invented. Instead, an improved use for an established material was evolved. The specialists recognized a market would exist for a lighter and stronger tank trailer for trucks which could, at costs competitive with other materials, withstand a variety of corrosive cargoes and at the same time could be quickly and easily cleaned to ensure interchangeability of payload.

One experimental unit was designed and built under the sponsorship of International Nickel. It was competitive in cost with other tank trailers and carried equal payloads for more than a year and 70,000 in-service miles. Today, some two years later, hundreds of tank trailers based on the original concept are being built for the trucking industry in North America and overseas. The original unit, incidentally, continues in active service.

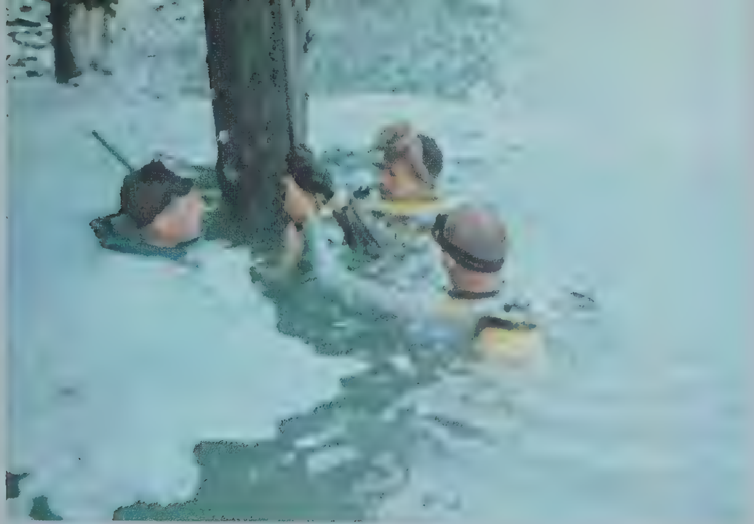
Members of International Nickel's U.S. market development committee meet to analyze marketing plans and to outline important projects. Headed by the manager of market development, the committee includes representatives of key departments.

Market Development Men in the Field

International Nickel's district office representative studies a test rack of metals atop a building in Los Angeles. Performance data garnered from such test racks in various parts of the world are important to builders and architects in choosing proper construction materials.

A nickel alloy propeller on a tugboat is examined and its in-service performance in a corrosive environment evaluated. Information on performance of nickel alloys gathered by research scientists and market development personnel is made available to industry.

Engineers inspect a model condenser installed in a large oil refinery at Yorktown, Virginia. Liaison with the petroleum industry has led to the development of many improved materials, such as copper-nickel alloys for condenser tubing, by International Nickel's development and research staff.



Neck-deep in their work, application engineers help to sheathe wooden piling with a nickel alloy sheet to protect it from marine organisms. Such assistance to industry and to nickel consumers is offered readily by market development specialists.

Literally out in the field helping create new markets for nickel, a scientist from International Nickel's Toronto office examines the improved condition of wheat in a test plot which has been treated with a nickel-containing rust fungicide currently under development. He is flanked by professors from the University of Manitoba's Department of Plant Science.

Hard hats are not uncommon headgear for market development personnel. Here, a specialist from International Nickel's office in Toronto is on the construction site as the new City Hall rises. With him are the project and supervising architects. The Toronto City Hall features nickel-stainless steel window framing and mullions, louvers and entrances.

International Nickel sponsors conferences and symposia as a means of disseminating technical and scientific information on nickel and nickel-containing materials. This scene is from a London symposium on austenitic cast irons, which was attended by representatives of the chemical, petroleum, electrical, aircraft, marine and agricultural industries of 10 countries.

At Monte Croce, on the heights overlooking Genoa, a demonstration was held recently to show the excellent behavior of 9 per cent nickel steel at cryogenic temperatures. International Nickel's technical manager in Italy (left) is shown here discussing the nature of the fracture with engineers after the cryogenic vessel had been tested to destruction at a pressure more than six-and-a-half times greater than its design pressure.

An important new market for nickel stainless steel is represented by these graceful light poles. Promoted by International Nickel's market makers, the one-piece octagonal poles are being installed on city streets in Canada, the U.S.A. and Europe. Those shown above are located in the Canadian National Exhibition grounds in Toronto.

Similarly, International Nickel's market development engineers are promoting acceptance of strong, lightweight and attractive nickel stainless steel light poles. The lighting standards are virtually maintenance-free, which can mean significant savings in the long run for taxpayers. Several cities in North America and elsewhere have already installed these poles.

None of these projects, it should be noted, involves nickel in its primary form. The marketing activities are concerned solely with products utilizing nickel-containing materials.

Other Means of Developing Markets

Development of new applications and new designs is not the only concern of International Nickel's market development staff. It also devotes much effort to manufacturing techniques to which nickel is especially adaptable. Development of new techniques and improvement of established ones has been of considerable help to manufacturers, particularly to small companies. This assistance to small business has led to several major markets for nickel.

One such market may prove to be electroforming. An established technique for producing an object by electrodeposition of a metal on a removable mold (or mandrel), electroforming has for many years been used for manufacture of industrial parts which, frequently, could not be formed economically in any other way.

Its promise, however, has never been sufficiently exploited for consumer items, International Nickel's market development men feel. The technique's unique capacity for reproduction of exact detail and finish, for production of intricate design, for achievement of close tolerances, make it ideal for economic manufacture of a variety of goods. These include beautifully detailed hollow ware, coffee percolators, wall switch plates, nameplates and even large items such as wash basins. In fact, all of these items are now either in the pilot stage of manufacture or already on the market as a result, in no small part, of concerted development effort.

Another promising target at which market development has taken aim is the whole field of cordless electrical appliances. The rechargeable nickel-cadmium battery promises to revolutionize the concept of electrically powered household appliances. These cells have already made their impact on the space and electronic industries. Their impact on the consumer market has just begun; International Nickel's market development staff is working vigorously in this area.

Even from the few examples cited here, it is apparent that nickel's capacity to serve industry and the consumer is vast indeed. All evidence seems to substantiate the belief that past progress and success with the metal give but an inkling of future achievements. If nickel's full potential is to be realized, however, much will depend upon the continued success of the market makers.

AS INDIA BUILDS

by
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About The Author: Dr. S. N. Anant Narayan has been managing director of International Nickel's Nickel Information Bureau Private Limited, Bombay, since 1959. For three years prior to that he was a member of the International Nickel organization's metallurgical research staff in Bombay. He is a graduate in mathematics of Madras University and a graduate in metallurgy of Banaras Hindu University. He received his master's degree and doctorate in metallurgy from the Colorado School of Mines. Dr. Narayan is a fellow of the Institution of Metallurgists, London; a member of the Institute of Metals, and a member of the Iron and Steel Institute. He has been a council member of the Indian Institute of Metals and is holder of the Institute's Pandya Memorial Award.

One of India's great achievements since she gained her independence in 1947 has, ironically, become the source of many of her economic problems. Improved sanitation and the effective control of such diseases as malaria which were once wholesale killers have resulted in a substantially reduced mortality rate. More people are living longer. At the same time, the birth rate has continued to climb. At 40.9 per thousand (compared to 18 per thousand in Western Europe and a rate of 21.6 in the United States), India's birth rate is one of the highest in the world. India's population today has been estimated at as high as 475 million —and it is making a net gain of almost 12 million annually.

With her population growing at such a rapid pace, it is obvious that India's herculean efforts to raise the living standards of her masses and modernize her economy have availed less than they might otherwise have. This is not to say that progress is not being

made. The difficulty is with the rate of progress.

As a result—to get the increased capital required by India's development program—there has been of late in Government circles a marked interest in encouraging private business. Last spring, for instance, Finance Minister T. T. Krishnamachari told the Indian Parliament that incentives should be offered to attract private investors from abroad. At that time he said, "We should especially welcome foreign investment in the shape of equity capital, which not only brings with it technical know-how and managerial skills, but has a special advantage of not adding to the heavy and growing burden of debt payments."

Building The Economy

Ever since 1951—a year after adoption of the constitution which established a republican form of government—India has been attempting to speed up the pace of her economic growth through a series of five-year plans. A study of the two plans already completed and of the third one which will be concluded in March 1966 reveals that the encouragement of private capital is not a sudden shift. A more favorable attitude toward the private sector has been evolving over the years. Such a study will tell us not only about the past; it may also reveal something of the future.

By comparing the achievements of the first two plans against their original targets and by observing how the pattern of the plans changed as time progressed, we can get an idea of what the future trends in India's industrial development might be.

Changes in the distribution of outlay in the public sector between the first and the second plans are significant. In the first plan, more importance was attached to agriculture and irrigation. Also, attempts were made to strengthen the basic foundations of the economy by increasing power output and by improving transport and communications. In the second plan, great stress was laid on basic industries, such as steel and heavy machinery, as well as on further improvement in transport and communications.

In spite of a greater tax effort to raise internal resources for the second plan, a large increase in external assistance was needed. The greater requirements of foreign exchange for the second plan were mainly due to the shift in emphasis towards basic heavy industries, which necessitated large-scale importation of capital equipment.

During the first ten years of planning, the record of growth was not uniform. The first plan was executed more or less smoothly, but in the very first year of the second plan, availability of foreign exchange became an acute problem. Taking the decade as a whole, the picture is one of over-all progress. The national income increased by almost 50 per cent during the ten years, but due to a big increase in population the per-capita income appreciated by only 16 per cent. Agricultural production recorded a substantial growth and certain basic industries made rapid strides.

The pattern of financing for the current plan is assumed to consist of almost $11.2 billion, or 72 per cent, from internal resources and over $4.6 billion, or 28 per cent, from foreign assistance, compared to a 90-10 ratio for the first plan and 76-24 for the second. This points up the importance attached to the development of domestic industries and also, as a consequence, the necessity for increased external financial assistance to pay for capital equipment imported for these industries.

During the course of the third plan, the country has been exposed to a serious threat to national security resulting from the Chinese invasion. The implementation of the plan has been greatly affected by this development. Before assessing its progress and discussing the future avenues for economic development, it is essential to analyze certain broad trends in foreign trade, foreign assistance and foreign investment which affect the realization of the plan's targets.

Balance of Payments

India's exports and imports of selected commodities for the years 1948-49 to 1961-62 are given in two accompanying tables. India has long depended on a few traditional commodities for her export earnings. Jute manufactures, cotton manufactures and tea account for some 50 to 55 per cent of total exports. Vegetable oils, raw cotton, hides and skins (raw and tanned), metallic ores, spices and cashew kernels make up 20 to 25 per cent. Over the last five years light engineering goods have emerged as a new export commodity, but they have not made any significant contribution to the over-all picture. As far as the immediate future is concerned, it is difficult to envisage any significant changes in the pattern of exports.

The pattern of imports has undergone considerable change from the pre-plan period to 1961-62, the last

Although India is working hard to develop her economy, in many parts of the country men, instead of machines, still do many of the back-breaking jobs. Here, Indian laborers construct an irrigation dam. (Courtesy U.S.I.A. Bombay)

year for which complete data are available. To a great extent the change in the structure of imports illustrates the accent on the development of basic heavy industries. The imports of capital goods as a category increased sharply by as much as 136 per cent over the ten-year period 1950-51 to 1960-61. Within this category, machinery increased by 134 per cent and "metals—iron and steel and manufactures" by more than 300 per cent. Raw materials in total imports declined, thanks to an improvement in the local supply of cotton and jute. In the field of consumer goods, the import of food grains continued at about the same level. But consumer durables showed a decline, due mainly to the very restrictive policy followed by the Government for this category of imports.

The balance of payments has been under pressure during all these years since it is closely tied with the trade balance. To a certain extent, the pressure has been relieved by external assistance and investment.

The regional pattern of foreign trade over the years is important since changes in this pattern may indicate the direction in which India's trade is likely to move in the future. The share of four trading areas in India's import-export business is shown by percentage figures in the table below:

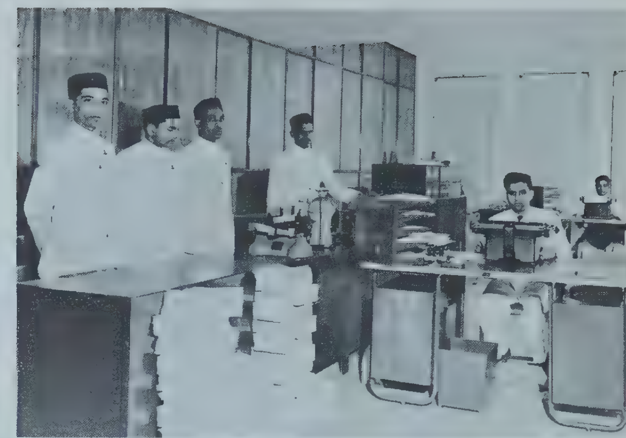
Regional Pattern of Foreign Trade

	Exports f.o.b.			Imports c.i.f.		
	1951-56	1956-61	1961-62	1951-56	1956-61	1961-62
Sterling area	54%	50%	44%	46%	38%	35%
Dollar area	21%	19%	21%	24%	26%	26%
O.E.E.C. countries	10%	9%	9%	16%	21%	20%
Rest of non-sterling area	15%	22%	26%	14%	15%	19%

Source: India's Balance of Payments by Reserve Bank of India.

Trade between India and the sterling area has decreased progressively, while the dollar area has increased her exports to India. There has been a steady increase in imports by India from countries of the Organization for European Economic Cooperation (since replaced by the Organization for European

Symbolic of India's economic emergence is this modern petroleum refinery in Bombay. In 1951, India launched the first of a series of five-year plans to speed up the pace of her economic growth.



The Nickel Information Bureau Private Limited in Bombay is one of many International Nickel offices throughout the free world. It provides technical counsel and information to India's nickel-using industries.

Economic Cooperation and Development) and the rest of the non-sterling area. If the last two groups are further analyzed to delineate the European Common Market and the East European countries, including the U.S.S.R., it is clear that trade has considerably increased between India and these groups.

Trade Policy

In the beginning of the first five-year plan, India had a fairly comfortable balance of payments position due to large sterling balances accumulated at the end of World War II. Imports were not regulated to any great extent then. With the increase in the tempo of

Imports of Selected Commodities (in millions of dollars)

	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61	1961-62
A. Capital Goods														
1. Machinery	172.4	248.0	191.6	212.8	202.3	200.8	183.2	253.1	272.8	374.1	282.3	325.9	428.2	487.8
2. Metals—iron & steel & manufactures	27.2	38.7	40.0	46.3	51.6	61.3	65.1	140.0	308.0	326.1	227.4	177.5	257.9	214.7
3. Metals—other	46.9	40.4	58.5	43.4	41.7	31.2	55.2	53.7	84.8	82.9	67.6	81.7	99.6	103.6
4. Transport equipment (incl. locomotives)	70.1	53.1	51.6	72.4	84.4	72.4	75.2	122.1	141.7	123.6	126.9	137.3	143.2	104.0
B. Raw Materials														
1. Mineral oils	75.2	112.8	116.0	149.3	161.9	178.1	173.3	115.6	158.1	229.7	150.6	182.7	146.3	201.9
2. Cotton, raw and waste	135.2	133.1	212.2	288.8	161.5	110.9	122.9	120.6	108.4	85.9	59.6	86.9	172.0	132.0
3. Dyes and colors	33.1	23.4	30.7	40.6	22.3	39.8	41.5	37.3	33.5	26.7	19.8	21.1	27.2	30.5
4. Chemicals (excl. chemical manures and medicines)	43.3	16.2	19.4	41.9	28.8	28.0	37.7	44.8	55.2	58.1	65.1	93.5	82.7	73.9
5. Raw jute	149.9	44.6	57.9	141.3	34.7	30.1	27.4	40.6	18.5	14.3	5.5	7.2	16.0	13.3
C. Consumer Goods														
1. Electrical goods and apparatus	24.2	29.7	20.4	21.7	34.3	31.8	24.2	32.6	103.8	132.8	100.4	112.0	120.4	132.6
2. Drugs and medicines	16.6	16.6	20.8	32.8	24.2	26.3	28.0	31.6	34.7	36.4	19.6	20.4	22.1	23.8
3. Rayon textiles (artificial silk yarn & piecegoods)	29.3	28.6	32.0	38.3	17.1	27.2	29.1	36.6	39.2	23.8	22.7	26.1*	28.6*	26.9*
4. Paper, pasteboard, etc.	32.4	21.5	21.9	31.4	29.7	28.0	28.8	34.3	29.3	25.7	16.8	23.6	25.5	33.1
5. Foodgrains (grain, pulse and flour)	213.7	281.7	169.3	484.8	327.4	134.3	143.8	36.8	17.1	127.6	381.5	314.7	381.9	203.8
D. Other	286.1	275.8	269.9	415.8	255.6	284.4	346.7	530.5	495.8	514.1	356.6	404.2	247.7	234.3
Total	[illegible]	[illegible]	1312.7	2091.7	1677.5	1254.6	1381.9	[illegible]	[illegible]	[illegible]	[illegible]	2012.6	[illegible]	[illegible]

Source: India's Director General of Commercial Intelligence and Statistics.
*Includes art silk thread.

industrialization and with the importation of capital equipment on a large scale, the second five-year plan ran into an exchange crisis in the very first year. The Government then introduced a very restrictive import policy and banned the imports of all non-essential and luxury-type consumer goods. Even for capital goods, the Government preferred imports under specific grants and credits. This import policy is likely to continue for many years to come since foreign exchange viability cannot be easily achieved in a short time.

The Government has appreciated the urgent necessity for the promotion of exports and has taken several measures in this connection. Export duties have been steadily removed or reduced, while export quotas have been liberalized and restrictions on exports to certain destinations have been lifted. Rebate on import duty on raw materials and components used in the manufacture of goods to be exported is allowed.

Attracting Foreign Investment

Foreign economic assistance to India has taken several forms. There have been grants, loans repayable

SOME ACHIEVEMENTS OF INDIA'S FIVE-YEAR PLANS

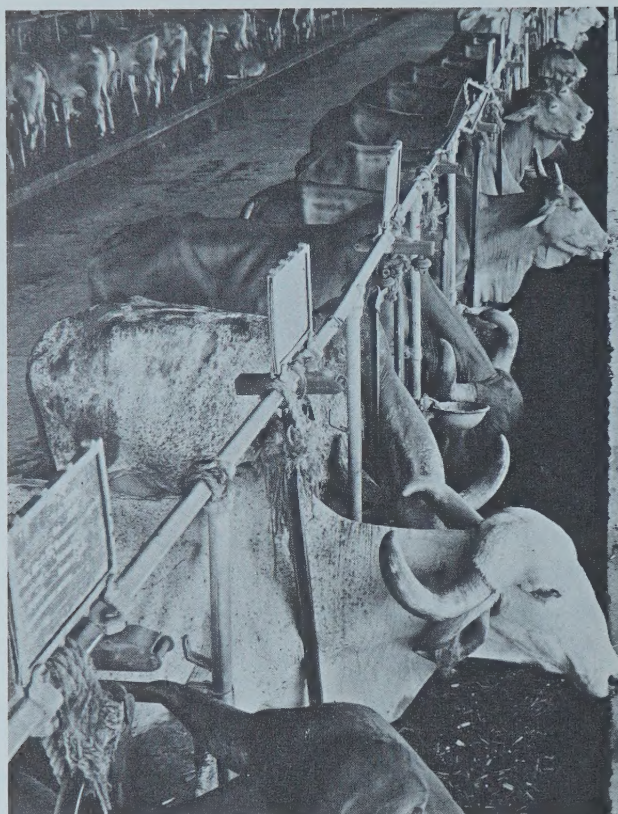
Item	Unit	1950-51	1955-56	1960-61	Percentage increase in '61 over '51
National income at '60-61 prices	Millions of dollars	21,558	25,537	30,526	42
Population	Millions	361	397	438	21
Per-capita income at '60-61 prices	Dollars	59.7	64.3	69.4	16
Index of agricultural production	1949-50=100	96	117	135	41
Index of industrial production	1950-51=100	100	139	194	94
Production of:					
Steel ingots	Million tons	1.4	1.7	3.5	150
Sulphuric acid	Tons	99	164	363	267
Petroleum products	Million tons	—	3.6	5.7	—
Coal	Million tons	3.2	4.3	10.7	234
Power: installed capacity	Million KW	2.3	3.4	5.7	148

Source: Plan Statistics.

Exports of Selected Commodities (in millions of dollars)

	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61	1961-62
A. Consumer Goods														
1. Tea	144.6	153.1	169.3	197.9	170.3	215.2	308.8	229.7	305.7	239.4	273.1	271.6	258.1	255.6
2. Cotton piecegoods (Mill-made and handmade)	76.2	124.6	248.4	109.9	130.7	133.9	133.3	119.2	132.9	122.7	95.8	133.3	121.3	101.9
3. Black pepper	5.7	30.5	42.9	48.8	33.9	27.2	14.7	9.9	7.2	6.1	5.3	17.3	17.9	17.1
4. Cashew kernels	10.3	11.8	18.1	18.9	27.4	23.2	22.5	25.3	30.5	32.0	33.5	33.7	39.8	38.3
5. Tobacco (manufactured and unmanufactured)	17.5	25.3	38.9	47.4	32.8	25.5	27.4	24.8	29.1	33.3	33.9	30.8	33.3	31.6
6. Oil cakes	0.21	0.21	—	—	—	0.21	3.2	11.2	3.6	5.9	22.3	44.2	30.1	36.4
B. Raw Materials or Intermediate Goods														
1. Jute manufactures	308.6	267.4	240.0	568.8	272.4	239.6	260.6	249.1	250.9	233.7	213.9	231.4	284.6	302.5
(a) Gunny bags	129.5	134.3	116.2	284.8	129.3	84.8	119.8	114.1	110.7	103.4	78.3	84.4	120.8	128.2
(b) Gunny cloth	169.9	120.4	110.7	262.3	132.8	146.1	131.6	124.4	128.0	119.4	126.7	137.7	156.6	167.6
(c) Others	9.3	12.6	13.1	21.7	10.3	8.6	9.3	10.5	12.2	10.9	8.8	9.3	7.2	6.7
2. Hides and skins, tanned	26.7	44.2	53.3	52.6	42.3	52.6	43.4	47.4	44.2	44.0	39.6	64.0	52.4	53.3
3. Hides and skins, raw	11.8	14.7	20.2	17.9	11.8	13.1	15.4	14.1	12.6	14.3	17.7	24.4	20.0	17.5
4. (a) Manganese ore	3.8	12.2	16.8	33.1	45.7	50.9	27.2	22.5	34.5	62.5	28.6	25.1	29.7	21.9
(b) Iron ore	—	—	0.42	2.1	7.8	12.2	8.8	13.3	19.6	24.8	20.6	30.9	35.8	36.8
(c) Other ores	—	4.2	3.2	4.4	26.5	15.2	9.5	12.8	14.7	10.7	11.2	20.2	17.3	18.1
5. Raw cotton	29.5	22.3	10.3	28.8	40.6	19.8	21.5	62.5	28.2	18.9	34.9	21.3	18.3	30.1
6. Cotton waste	10.7	17.3	26.1	15.6	20.2	20.8	21.1	20.4	14.9	11.6	12.6	9.3	6.1	8.4
7. Vegetable oils	22.9	16.0	53.3	49.7	56.0	10.3	42.1	72.4	32.8	22.3	13.5	31.2	17.9	12.2
8. Oil seeds	14.7	31.2	33.7	13.7	8.6	3.4	7.6	7.4	0.21	0.21	4.0	5.3	10.7	8.8
C. Other	282.3	290.5	290.9	333.5	288.2	254.1	280.4	338.1	342.7	298.7	345.1	352.4	367.4	434.5
Total:	965.7	1065.5	1265.9	1543.2	1215.4	1117.1	1247.4	1281.9	1304.4	1181.3*	1205.5	1346.1	1360.6	1425.1

Source: India's Director General of Commercial Intelligence and Statistics.
*Excludes exports of silver to U.S.A. in fulfillment of lend-lease obligations.



To feed her large population, India has substantially increased agricultural production in recent years. Modern dairies such as this are producing more milk for India's millions.
(Courtesy U.S.I.A. Bombay)

in foreign currencies, loans repayable in rupees and short-term assistance from the International Monetary Fund to assist the balance of payments. Surplus agricultural commodities have been made available by the United States on rupee payment, and loans and grants have been given from such counterpart funds. Deferred credit has been allowed by several machinery suppliers. Technical assistance has been available on a fairly large scale. From the middle of the second five-year plan, foreign assistance has been an integral part of the economy. It is now recognized by all concerned that without sizable external assistance, the country cannot sustain her development from export earnings alone.

Even more valuable than foreign assistance in the development of the Indian economy, the Government has realized, is private foreign investment in the form of capital or equipment. Several measures have been taken recently to attract private foreign investment. An investment center has been opened in New York to provide information to prospective investors. Several tax concessions have been made to foreign investment in the recent budget. Further, the Government has affirmed that India will guarantee the safety of investments and returns thereon and that India does not regard nationalization of industry as a goal. Moreover, the Government has entered and is willing to enter with other countries into programs to guarantee against non-convertibility and expropriation.

The Future

India, in the midst of her third plan, is already engaged in outlining the targets for her fourth five-year plan. It is postulated that the outlay in the fourth plan will have to be at least twice that of the third plan to insure a steady increase in national income.

It is probable that some of the targets originally outlined in the current plan may not materialize due to some current problems like the unforeseen large outlay in defense, pressure on prices, and lag in agricultural production. But these difficulties are expected to be overcome in the course of time.

It is recognized that the foreign exchange requirements of the country will continue to be a problem for some years to come and the trade policy of the country will be influenced accordingly. Priority will be given to imports of capital goods, components for running the existing machinery and finally raw materials that are not indigenously available. Imports of consumer goods will be severely restricted.

The fundamental aim of planning in India is to raise living standards. Massive capital imports are necessary for this purpose. These imports will have to be financed by export earnings, capital loans from abroad, gifts and foreign investment. Importance is attached in the plan to programs of industrial development to effect import savings. This does not mean that in the course of five, ten or 15 years the import requirements of India will decline. On the contrary, it is likely that as the economy moves towards higher stages of development new types of imports will be necessary to sustain the progress.

In the drive for rapid development, the economy of the country is bound to be afflicted periodically with stresses and strains. Ultimately, however, India expects to emerge with a standard of living comparable to other highly industrialized countries. She looks forward to the day when she will take her place as a vigorous partner in international trade.

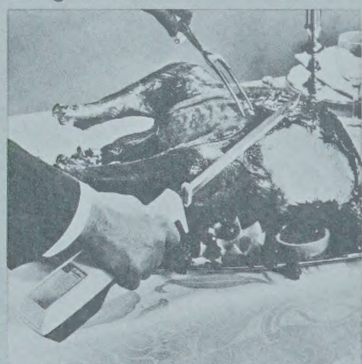
something really different

Last summer on this page, we showed the nickel-cadmium battery at work in industry. Now we present this rechargeable, long-lived source of portable power as it serves on the domestic scene.

Rechargeable nickel-cadmium batteries, which have made possible a wide gamut of conveniently cordless electrical appliances, have also come to the assistance of the harried shopper who's looking for a gift that's "really different." A few of the latest products that combine both novelty with practicality are pictured here. They are but a snippety sampling from a large—and still expanding—assortment.

For toys, flashlights, portable radios, recorders and a variety of other applications, here are D-cell nickel-cadmium batteries that can be recharged over and over again. Nickel-cadmium batteries are reliable and durable power sources which minimize the continuing problem of replacing batteries. Recharging equipment is simple, and can be built into the electrical device or used separately, as shown here. This set is sold by a leading battery manufacturer.

The pater familias can execute his carving chores with aplomb if he's lucky enough to wield an electric slicing knife. The General Electric Cordless Knife shown here weighs, with batteries, less than two pounds. The power is provided by nickel-cadmium batteries which are automatically recharged when the knife is put into the storage rack.



"She shall have music wherever she goes . . ." and in stereo, at that! The "Voyager" cordless stereo phonograph, by V-M, the Voice of Music, operates continuously for a minimum of six hours, without the need for recharging, on a nickel-cadmium battery. The battery restores itself to full capacity during an overnight charge. A slow "trickle" charge will keep the battery at full capacity while the instrument is playing from the normal house current. The four-speed machine, with battery, weighs only 25 pounds.

This cordless electric shoe polisher, just introduced on the market by Empire Brushes, Inc., is powered by three small rechargeable nickel-cadmium batteries. It is the main feature of a 10-piece shoe care set that includes a battery recharger and pairs of daubers, brushes and buffers.

For more about nickel-cadmium batteries and a list of the leading battery manufacturers, write for the booklet "Key To A Cordless World." Address:

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